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Determining Input Variables for Calculation of Impact of New Source Performance Standards Worksheets for Miscellaneous Sources

Research Corporation of New England, Wethersfield, Conn.

Prepared for

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DETERMINING INPUT VARIABLES FOR CALCULATION OF IMPACT OF NEW SOURCE PERFORMANCE STANDARDS: WORKSHEETS FOR MISCELLANEOUS SOURCES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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16. ABSTRACT

The purpose of this document is to present the results of a study to determine the impact of new source performance standards on nationwide emissions. The work presented covers 14 potential pollutants from approximately 200 source categories for the year 1985. The results are being used by EPA as input to the development of an overall standard setting strategy. The report contains information regarding controlled and uncontrolled emission factors, State emission limitations, industrial capacity, utilization, growth and retirement rates. The results of this study have been published as three volumes which encompass ten separate documents. This document contains Appendices 4F through 4I of Volume II - Calculation Sheets for Evaporation Loss Sources, Petroleum Industry, Wood Products Industry, and Assembly Plants.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS		c. COSATI Field/Group
Air Pollution Air Pollution Control Industrial Processes Combustion Regulations Economic Factors	Priorities Chemical Industry Paper Industry Petroleum Industry	Metal Industry Agricultural Mineral Flyash Exhaust Gases	

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by

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Contract No. 68-02-1382

EPA Project Officer: Gary D. McCutchen

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
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April 1977

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Publication No. EPA-450/3-76-018-f

FOREWORD

During 1974, two studies were initiated that ultimately resulted in the establishment of priorities for developing and promulgating New Source Performance Standards (NSPS). The procedures used to determine these priorities produced a great deal of information that is believed to be useful in the industries involved and, accordingly, is being published in this series of reports (EPA-450/3-76-017, EPA-450/3-76-018, EPA-450/3-76-019, and EPA-450/3-76-020). This information is organized as follows:

EPA-450/3-76-017 discusses (1) the mathematical model (Model IV) used to determine NSPS impacts over a 10-year period; (2) the methods used to attain input variables; and (3) the summary tables which are the heart of this study. Included in the summary tables are data related to (1) emission, growth, and replacement rates; (2) present and future production and capacity; (3) nationwide emissions; and (4) NSPS impact. These tables include information on 13 pollutants and nearly 200 stationary source categories.

EPA-450/3-3-76-018-a, -b, -c, -d, -e, and -f are the calculation sheets, showing how the input variables reported in EPA-450/3-76-017 were derived. All information sources, assumptions, and calculations are documented and explained. The appropriate worksheets are arranged alphabetically in the following volumes:

018-a - Stationary Combustion Sources

018-b - Chemical Processing Industries

018-c - Food and Agricultural Industries

018-d - Mineral Products Industries

018-e - Metallurgical Industries

018-f - Miscellaneous Sources (Evaporation Losses, Petroleum Industry, Wood Products Industry, and Assembly Plants

The 018-a -f series is of interest only to those concerned with the detailed calculations used to determine the Model IV input variables.

EPA-450/3-76-019-a provides additional results and information produced during the priority study. Its major purpose is to describe the computer program used to rank all the Model IV input and output variables by pollutant (these rankings are reported in 019-b and -c). In addition, it contains (1) summaries of the control systems considered "best" for each source, (2) equipment retirement ages, and (3) emission trends for each source category.

EPA-450/3-76-019-b and c present the computer-generated ranked data for each pollutant. Ranking is from highest to lowest for each of the 21 variables, e.g., A (nationwide capacity) and E_u (uncontrolled emission rate). Volume 019-b contains ranked data for particulate, nitrogen oxide (NO_x), and sulfur oxide (SO_x) sources. In Volume 019-c, the remaining pollutant sources are ranked: hydrocarbons, carbon monoxide (CO), fluorides, hazardous material, acid mist, lead, ammonia, sulfides, chlorine, and trace metals.

EPA-450/3-76-020, the final document in this series, takes the objective impact values from EPA-450/3-76-017, adds subjective judgements, and uses these combined criteria to produce a priority list for NSPS development. The report then calculates nationwide emission trends over the next 15 years for each criteria pollutant (particulate, SO_x, NO_x, hydrocarbons, and CO) based on a series of scenarios (e.g., no NSPS, 20 NSPS per year, etc.)

In summary, documents EPA-450/3-76-017 and 020 present the results of this study. Each stands alone, but they also complement each other, with 020 building on the results of 017. The remaining documents (018-a -f and 019-a -c) present additional and/or more detailed information derived from the impact and priority studies.

DETERMINATION OF INPUT VARIABLES
FOR
EVAPORATION LOSS SOURCES

TRC -- The Research Corporation of New England
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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By ______ Date 9/12/74

Source Degreasing

Ref (74) p III-62 states total estimated annual hydrocarbon emissions ranging from 1.3 to 1.9 billion pounds per year. Since most data in this reference are from 1968, we will assume this emission to be in 1968.

Ref (51) p3 Table 1 states $E_u = 1.5 \frac{\text{lb}}{\text{ton metal cleaned}}$

$$\left(\frac{1.3+1.9}{2}\right)\left(10^9\right)\frac{\text{lb}}{\text{yr}} = \left(1.5\ \frac{\text{lb HC}}{\text{ton metal}}\right)\left(\frac{\text{ton metal}}{\text{yr}}\right)$$

$$\frac{\text{ton metal}}{\text{yr}} = 1.07 \times 10^9$$

No specific value of "K" could be located. However, ref (74) states that a large portion of degreasing operations occur in the automobile and aircraft industries (p III-62).

Ref (144) p 28 however gives $K_{\text{auto mfg}} = 0.91$ and

$$K_{\text{aircraft}} = 0.73$$

We will use the average of these two values to be representative of degreasing operations as a whole.

$$\boxed{K = 0.82}$$

0.91
0.73
2 | 1.64
.82

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Project Number - 32391 New Source Performance Standards

Computation Sheet for Industrial Factors

Calculations Done By [illegible] Date 7/18/74

Source Degreasing

Ref (24) p III-48 shows that trichloroethylene is the principal solvent used for degreasing. One method of determining the growth rate (R) [illegible] degreasing operations would be to relate it to the growth of trichloroethylene

$R_{c_{TCE}} = 3.5\%$ Ref (24)

Another method is to relate it to the growth in the production of metal parts which must be degreased. One large industry which does a substantial amount of degreasing is the automotive industry. Work done by TRC on this project shows

$R_{Auto\ Assy} = 2.9\%$ see "Industrial Factors" for "Automobile Assembly Plants"

We will assume the average

$\boxed{R_{c_{degreasing}} = 3.2\%}$ compound

$A = \frac{1.07\times10^{9}(1.032)^{9}}{(.88)} =$ [illegible] $\times10^{9}$ tons

A = 1.6[illegible] $\times10^{9}$ tons metal

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 10/25/84

Source Degreasing

Der'n Of P_d

REF (37) p 34

IRS DEPRECIATION GUIDELINE FOR

"MANUFACTURE OF FABRICATED METAL PARTS - 12 YRS

" MANUFACTURE OF OTHER MACHINERY - 12 YRS

ALSO FROM p 35

"MOTOR VEHICLE MANUFACTURING ASSETS - 12 YRS

Assume P_d = 2 (IRS GUIDELINE) = 24 yrs

$$P_d = \frac{100\%}{24\,\text{yrs}} = 4.17\%$$

$$\boxed{P_d = 0.0417}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Date 9/13/79

Source Degreasing

(HYDROCARBONS)

Per ㉞ p8 TAB 1

$$\boxed{E_N = 1.5 \frac{\#}{\text{TON METAL}}}$$

Per ㊻ p874 CARBON ADSORPTION

$$\eta = 90\%$$

$$E_N = 1.5(.1) = 0.15$$

$$\boxed{E_N = 0.15\ \#/\text{TON METAL}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10-25-74

Source Degreasing

HC: ~~[illegible]~~

From Ref. 34, p 8 TABLE 1, we know that a typical degreasing unit will clean 200,000 LB of metal/day. This results in uncontrolled emissions of

$$\left(E_u = 1.5\ \text{LB/TON}\right) \times 100\ \text{TON/DAY} = 150\ \text{LB HC/DAY}.$$

Since many states do not have HC regulations which apply to stationary sources,* and we do not have a state-by-state distribution of degreasing process volume, we estimate E_s by the following procedure:

a) ~~[illegible]~~ Sixteen (16) states have regulations governing HC emissions.* The typical regulation restricts emissions to either 40 LB/DAY or 85% emission control (in this case, the 40 LB/DAY limit would apply.)

b) The remaining states have no applicable regulations, hence for them $E_s^i = E_u^i$.

Assuming in order to estimate E_s that degreasing units are distributed uniformly among all states, we find

$$E_s \simeq \frac{(16\ \text{STATES}) \times 40\ \frac{\text{LB}}{\text{DAY}} + (34\ \text{STATES}) \times 150\ \frac{\text{LB}}{\text{DAY}}}{50\ \text{STATES}} = 115\ \text{LB HC/DAY}$$

(Continued next page)

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Project Number 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10-25-74

Source Degreasing

HC. (Cont.)

Converting E_s to process weight units, we obtain

$$\boxed{E_s = \left(115\ \frac{\text{LB HC}}{\text{DAY}}\right) \Big/ \left(100\ \frac{\text{TONS METAL}}{\text{DAY}}\right) \cong \frac{1.15\ \text{LB HC EMISSION}}{\text{TON METAL CLEANED}}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By R.J. Marrone Date 8-7-74

Source Dry Cleaning

In Ref. 076 pg 4.1-1 it is estimated that 18 lbs/capita per year are cleaned in moderate climates and 25 lbs/capita per year are cleaned in colder areas.

We will use an average value for the per capita usage rate.

$$\frac{18+25}{2} \cong 22 \text{ lb/capita per year}$$

The US is probably represented more as a moderate zone on the average so that this average value may be slightly high.

A: According to a Telecom with Mrs Harris of the Bureau of the Census

Pop resident 1974 = 211.3×10^6 persons

Range of Pop est 1975 213.4×10^6 to 215.9×10^6 (a four step fertility range)

We will use an average population for 1975 of 214.6×10^6 persons

then: $22 \frac{\text{lb cloth}}{\text{person}\cdot\text{yr}} \times 214.6 \times 10^6 \text{ persons} \times \frac{\text{Ton}}{2000 \text{ lb}}$

$$\boxed{A = 2.36 \times 10^6 \text{ Tons clothes/yr}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By R.J. Massarone Date 8-16-74

Source Dry Cleaning

K: Since the production capacity in tons [illegible] clothes are based on the population and a per capita usage factor. In this case, the utilization factor K has an interpretation of unity

$$\boxed{K = 1}$$

P_c: The dry cleaning of clothes is linked directly to the population. This is confirmed by using the usage factor of 22 lb/capita for the estimate of total production capacity.

The growth of dry cleaning will then be identical to the population growth. This assumes a constant of 22 lb/capita.

		Growth Rate %
Ref 106	1969-1970	2.2
	1970-1971	2.17
	1971-1972	1.19
Ref: Telecon Bureau of Census Mr. Russell	1974-1975	est 1.5 → 2.0 high → 1.0 low

Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By R.J. Maggiore Date 8-16-79

Source Dry Cleaning

P_c: cont'd

The recent trend in population growth has shown a definite decline in the rate.

Historical info (1950's) has report 3% pop growth rates whereas annual figures are dropping to nearly half that rate, in recent years

Growth is, oddly enough, influenced by many factors; economy, religion, morality, technology, health, politics, etc... It is difficult to predict the course of the current trend.

We believe that the growth rate has reached its minimum. As an estimate we will assume a ~~[illegible]~~ growth rate of 1.8% which corresponds to the lowest fertility rate est. Therefore;

$$\boxed{P_c = .018 \quad \text{compound}}$$

~~[illegible]~~

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 9-26-74

Source Dry Cleaning

Ref. 037 pg 44 Section 70.2

Assume that dry cleaning deductions may be covered under this section of the IRS Table.

Asset depreciation life 10 yrs

P_s est 2×IRS = 20yrs

100% Depreciation in 20yrs $\frac{100\%}{20\text{yrs}} = 5\%/\text{yr}$ simple

$$\boxed{P_s = .05 \text{ simple}}$$

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Project Number - 32201 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By RJ [illegible] Date 7-31-74

Source Dry Cleaning
Hydrocarbons

E_u: Reference 075 pg 4.2-2 Table 4.1-1

Uncontrolled HC emissions:

Petroleum Plants = 305 lb/Ton clothes
Synthetic Plants = 210 lb/Ton clothes

the above source states that it is reported that 50% of the weight of clothes drycleaned today uses perchloroethylene (synthetic)

It is interesting to note that Ref. 074 pg III-63 interprets incorrectly the above finding. It says that 50% of the plants use synthetic solvents however it is actually 50% of the weight of clothes and 70% of the plants.

Using the 50-50 breakdown by weight of clothes for synthetic and petroleum dry cleaning plants we calculate and average emission factor for uncontrolled dry cleaning source as;

$$\boxed{E_u = \frac{305 + 210}{2} = 258 \ \frac{\text{lb}^{HC}}{\text{Ton clothes}}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By William [illegible] Date 8-7-74

Source Dry Cleaning

Hydrocarbons cont'd

E_N: Ref 098 pg 4-32 Section 4.8.4;

Water cooler — activated carbon control system is being used and is attractive to the synthetic plants in this industry. Overall efficiency achieved 97-98%.

Petroleum plants are not presently controlled to any extent basically due to economics. Control is feasible by carbon adsorption or thermal incineration, however. We did not obtain from the literature efficiency estimate yet we may assume that at least a 95% eff could be achieved.

Since synthetic and petroleum plants handle equal weight of clothes we may estimate an average efficiency by

$$\frac{97.5 + 95}{2} = 96.25\%$$

We will use 96.5% eff

$$E_N = .035 \times E_U = .035 \times 258 \text{ lb/ton clothes}$$
$$= 9.03 \text{ lb/ton cl.}$$

$$\boxed{E_N = 9 \text{ lb/ton clothes}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By 2J Marrone Date 10-10-74

Source Dry Cleaning

E_6: Hydrocarbons

Using the following data we estimate the typical plant size for both synthetic and petroleum dry cleaning plants.

① Average Emissions in terms of lb HC/day for an average plant based on a survey of 1000 synthetic plants and 200 petro plants Ref. 046 p879

Synthetic Plants: 30 $\frac{\text{lb HC}}{\text{day}}$ for average plant

Petroleum Plant 175 $\frac{\text{lb HC}}{\text{day}}$ for average plant

② Using uncontrolled emission factors from Ref. 075 Table 4.1-1

$$E_{syn} = 210 \frac{\text{lb HC}}{\text{TON clothes}}$$

$$E_{pet} = 305 \frac{\text{lb HC}}{\text{TON clothes}}$$

③ 50% of the weight of clothes is dry cleaned in each type of dry cleaning plant

$$\frac{2.36}{2} \times 10^6 = 1.18 \times 10^6 \frac{\text{TON clothes}}{\text{yr}} \text{ or } \frac{1.18 \times 10^6}{365} = 3.23 \times 10^3 \frac{\text{TON clothes}}{\text{day}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-10-74

Source Dry Cleaning

II$_c$. Hydrocarbons cont'd

Typical Plant size: Synthetic; $\frac{30 \frac{\text{lb HC}}{\text{day}}}{210 \frac{\text{lb HC}}{\text{ton clothes}}} = .143 \frac{\text{ton cloth}}{\text{day}}$ per plant

Petroleum; $\frac{175 \frac{\text{lb HC}}{\text{day}}}{305 \frac{\text{lb HC}}{\text{ton clothes}}} = .574 \frac{\text{ton cloth}}{\text{day}}$ per plant

Number of Plants: Synthetic; $\frac{3.23 \times 10^3 \text{ ton clothes/day}}{.143 \text{ tons/day / plant}} = 22.59 \times 10^3$ plants

Petroleum; $\frac{3.23 \times 10^3 \text{ ton cloth/day}}{.574 \text{ ton cloth/day / plant}} = 5.63 \times 10^3$ plants

Relative Distribution by Type

Synthetic = $\frac{22.59}{28.22}$ = 80%

Petroleum = $\frac{5.63}{28.22}$ = 20%

This doesn't agree very closely with the 70/30% split developed under the calculation but is in sufficient agreement.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrow. Date 10-10-74

Source Dry Cleaning

E_1 : hydrocarbons cont'd

We will obtain a "typical" plant size for the dry cleaning industry by applying the percentage breakdown or in a sense weighting the plant sizes between synthetic and petroleum plants.

$$\text{Typical Size} = (.8 \times .143 + .2 \times .574) \ \frac{\text{TON clothes}}{\text{day}}$$

$$= .1144 + .1148$$

$$\text{T.S} \cong .229 \ \text{TON clothes/day}$$

or

$$458 \ \text{lb clothes/day}$$

$$\text{Emissions per plant} = .229 \ \frac{\text{Ton clothes}}{\text{day}} \times 258 \ \frac{\text{lb HC}}{\text{Ton clothes}}$$

$$\cong 59 \ \text{lb/day HC}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-30-74

Source Dry Cleaning

E_5 : cont'd Hydrocarbons 7

Since we have determined that the typical dry cleaning plant would emit 59 lb HC/day and ;

① Dry cleaning solvents (i.e. perchloroethylene, Stoddards, etc) are non-reactive

② Most states have no limitation on non-reactive hydrocarbon emissions

③ Those states which have a regulation pertaining to non-reactive solvents either have a value identical to LA Rule 66 3000 lb/day or comparable (i.e. Connecticut 800 lb/day)

④ No state limits the emission of non-reactive hydrocarbon to a level less than 59 lb/day

We determine that for non-reactive treatment of dry cleaning emissions, the value of E_5 would in reality be much larger than E_4. In this case we will assume that E_5 (to be applied) will be identical to E_4

$$E_5 = 258 \frac{\text{lb HC}}{\text{Ton clothes}}$$ (This is equivalent to 59 lb/day)

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 1/8/75

Source Graphic Arts

The printing and publishing industry is composed of more than 43,000 establishments and is recognized as the domain of the small businessmen since 80 percent of these establishments employ fewer than 20 persons. (Ref 020, p. 1)

In the printing industry the term "production rate" is rather ambiguous since the product of the industry is the placing of a printed image on paper, metal, plastic or other material. We have decided that the best parameter to use to define the industry is the ink usage for each printing process. There are five printing processes which account for the majority of ink consumption and almost all of the major pollutant of the industry — hydrocarbons. These five processes are the following:

1) Gravure
2) Flexography
3) Lithography
4) Letterpress
5) Metal Decorating

Therefore we have organized this industry by giving A, E_U, E_N + E_S values for each of the five printing processes. Because of the lack of substantial data we give K, P_C + P_B values for the industry as a whole. Industrial factors are expressed as TONS of ink consumed/yr while emission factors are expressed as lbs of hydrocarbons/TON of INK consumed.

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Project Number - 32351 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 1/9/75

Source Graphic Arts

Ref. 220 states that the growth rate of ink usage is expected to remain at 5% each year. This we assume is an accurate assessment of the growth of the printing industry as a whole.

$$\boxed{P_c = .050 \text{ compound}}$$

There was no specific data relating production to capacity for the individual printing operations so we assumed that the fractional utilization rate of the printing industry the same as that given by ref. 144 for all machinery manufactures (except electrical) ⟶ .88 This value represented an average value for the years 1965-1972

$$\boxed{K = 0.88}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By K Tower Date 1/9/75

Source Graphic Arts

Ref 050, p.8 gives the following table of ink consumption and solvent emission from the printing industry in 1968. All printing operations consume additional solvent to that supplied in the inks. The total solvent used for each printing process was obtained therefore by totaling the solvent from the ink and the solvent used for cleanup washes, additives, thinners, etc. We make the assumption that all this solvent evaporates and is emitted to the atmosphere.

Printing Process	Ink Coatings (million lb)	% Solvent in Ink Coating	Total Estimated Solvent Used s (million lb.)
Gravure	152.0	40	177
Flexography	66.5	80	160*
Lithography	81.5	35	114
Letterpress	143.0	35	105
Metal Decorating	60.5	60	112

# This value is different from that actually shown in the table from ref 050 which was 0. 0 appears to be in error so we calculated the actual value using $\frac{\text{solvent not in ink}}{\text{solvent in ink}}$ ratios shown in ref 050, p. 7.

$$A_{\text{Gravure}} = \frac{\text{Prod}_{1968}}{K}\left(1 + P_c\right)^{1975-1968}$$

$$= \frac{\frac{153.0\times10^6 \text{ lbs}}{\text{YR}}}{2000 \text{ lbs}/\text{TON}}\left(1 + .040\right)^7 = .122 \times 10^6 \frac{\text{TONS INK}}{\text{YR}}$$

20 $$\boxed{A_{\text{Gravure}} = 0.122\times10^6 \frac{\text{TONS INK}}{\text{YR}}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 1/2/75

Source Graphic Arts

$$A_{Flexography} = \frac{Prod_{1969}}{K_c}\left(1+P_c\right)^{1976-1969}$$

$$= \frac{\left(66.5\times10^6\ \frac{lbs}{YR}\right)\left(1+.054\right)^7}{(.88)\left(2000\ ^{lbs}/_{ton}\right)} = .053\times10^6\ \frac{TONS}{YR}$$

$$\boxed{A_{Flexography} = .063\times10^6\ \frac{TONS}{YR}\ INK}$$

$$A_{Lithography} = \frac{Prod_{1969}}{K_c}\left(1+P_c\right)^{1976-1969}$$

$$= \frac{\left(81.5\times10^6\ \frac{lbs}{YR}\right)\left(1+.050\right)^7}{(.88)\left(2000\ ^{lbs}/_{ton}\right)} = .065\times10^6\ \frac{TONS}{YR}$$

$$\boxed{A_{Lithography} = .065\times10^6\ \frac{TONS}{YR}\ INK}$$

$$A_{Letterpress} = \frac{Prod_{1969}}{K_c}\left(1+P_c\right)^{1976-1969}$$

$$= \frac{\left(143.0\times10^6\right)\left(1+.050\right)^7}{(.88)\left(2000\ \frac{lbs}{ton}\right)} = .114\times10^6\ \frac{TONS}{YR}$$

$$\boxed{A_{Letterpress} = .114\times10^6\ \frac{TONS}{YR}\ INK}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By K. Tower Date 1/3/75

Source Graphic Arts

$$A_{\text{Metal Decorating}} = \frac{\text{Prod}_{1968}}{K}\left(1+P_c\right)^{1975-1968}$$

$$= \frac{\left(60.5\times10^6\,\frac{\text{lbs}}{\text{yr}}\right)\left(1+.050\right)^7}{(.89)\left(2000\,\frac{\text{lbs}}{\text{ton}}\right)} = .048\times10^6\,\frac{\text{tons}}{\text{yr}}$$

$$\boxed{A_{\text{Metal Decorating}} = .048\times10^6\,\frac{\text{tons}}{\text{yr}}}$$

Ref. 037, p. 23, section 27.0 states that the asset guideline period for Printing, publishing and allied industries is 11 yrs. Assuming twice the IRS allowable:

$$P_B = \frac{1}{(2)(11)} = .045$$

$$\boxed{P_B = .045_{\text{simple}}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/2/76

Source Graphic Arts

Refering to the previous table (ref 050, p. 8), E_u values for each of the printing processes can be obtained by dividing the total estimate of solvents used by total amount of ink coating used. We assumed all the solvent used was emitted to the atmosphere.

$$E_{u_{\text{Gravure}}} = \frac{177 \times 10^6 \text{ lbs emissions} \left(2000 \frac{\text{lbs}}{\text{ton}}\right)}{\left(153.0 \times 10^6 \text{ lbs Ink used}\right)} = 2300 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{u_{\text{Gravure}}} = 2300 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

$$E_{u_{\text{Flexography}}} = \frac{160 \times 10^6 \text{ lbs emissions} \left(2000 \frac{\text{lbs}}{\text{ton}}\right)}{\left(66.5 \times 10^6 \text{ lbs Ink Used}\right)} = 4800 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{u_{\text{Flexography}}} = 4800 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

$$E_{u_{\text{Lithography}}} = \frac{114 \times 10^6 \text{ lbs emissions} \left(2000 \frac{\text{lbs}}{\text{ton}}\right)}{\left(81.6 \times 10^6 \text{ lbs Ink Used}\right)} = 2800 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{u_{\text{Lithography}}} = 2800 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

$$E_{u_{\text{Letterpress}}} = \frac{105 \times 10^6 \text{ lbs emissions} \left(2000 \frac{\text{lbs}}{\text{ton}}\right)}{143.0 \times 10^6 \text{ lbs. Ink Used}} = 1500 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{u_{\text{Letterpress}}} = 1500 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/3/75

Source Graphic Arts

$$E_{u\ \text{Metal Decorating}} = \frac{112 \times 10^6 \text{ lbs emissions } \left(2{,}000 \frac{\text{lbs}}{\text{Ton}}\right)}{60.5 \times 10^6 \text{ lbs Ink Used}} = 3700 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{u\ \text{Metal Decorating}} = 3700 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

Ref 050 p.6 states that efficiencies of up to 99.9% can be obtained on Gravure printing processes with the use of adsorption.

$$E_{N\ \text{Gravure}} = .001 \times E_{u\ \text{Gravure}} = .001 \times 2200 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}} = 2.2 \frac{\text{lbs}}{\text{Ton}}$$

$$\boxed{E_{N\ \text{Gravure}} = 2.2 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

Ref 059 p.6 also states that efficiencies up to 99+% can be obtained on all printing processes with the use of thermal incineration

$$E_{N\ \text{Flexography}} = 4800 \frac{\text{lbs}}{\text{Ton}} \times .01 = 48 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{N\ \text{Flexography}} = 48 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

$$E_{N\ \text{Lithography}} = 2800 \frac{\text{lbs}}{\text{Ton}} \times .01 = 28 \frac{\text{lbs}}{\text{Ton}}$$

$$\boxed{E_{N\ \text{Lithography}} = 28 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

$$E_{N\ \text{Letterpress}} = 1600 \frac{\text{lbs}}{\text{Ton}} \times .01 = 16 \frac{\text{lbs}}{\text{Ton}}$$

$$\boxed{E_{N\ \text{Letterpress}} = 16 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/9/75

Source Graphic Arts

$$E_{N_{\text{Metal Decorating}}} = 3700 \frac{\text{lbs}}{\text{Ton}} \times .01 = 37 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$\boxed{E_{N_{\text{Metal Decorating}}} = 37 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

Recent experimentation (ref. 050, p.6) shows the possibility of reducing these emissions still further with use of low solvent and water solvent inks.

Ref 050, p.8 states that based on measured emissions only lithography and metal decoration will be required to control emissions. Therefore $E_S = E_U$ for Gravure, Flexography and Letterpress printing operations.

$$E_{S_{\text{Gravure}}} = 2300 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$E_{S_{\text{Flexography}}} = 4800 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$E_{S_{\text{Letterpress}}} = 1600 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

Ref 248, p. 155 gives some coating process parameters for a metal decorating printing operation. We assume this plant to be an average plant.

$127.2 \frac{\text{lbs}}{\text{hr}}$ ink consumption

41 % solvent

$$127.2 \frac{\text{lbs}}{\text{hr}} \times .41 = 52.2 \frac{\text{lbs solvent emitted}}{\text{hr.}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By K. Tower Date 1/2/75

Source Graphic Arts

Ref 050, p. 8 states that over half of all commercial printing is performed in four states: New York, Illinois, Pennsylvania, and California. All of these states have enacted regulations similar to the L.A. rule 66 which states that emissions of all solvents which are heated must be limited to 3 lbs/hr, 15 lbs/day or be reduced by 85%.

In order to compute E_s for metal decorating we made the following assumptions: (ref 249, p. 16)

1) The average metal decorating printing process emits 52.2 $\frac{\text{lbs solvent}}{\text{hr}}$.
2) Since 85% reduction of 52.2 $\frac{\text{lbs}}{\text{hr}}$ gives a value (7.8 $\frac{\text{lbs}}{\text{hr}}$) greater than 3 lbs/hr, the applicable regulation for those states which operate under rule 66 is 85% reduction of emissions.
3) For those states (73%) which do not have hydrocarbon regulations, $E_s = E_u$, ref 84, p. 69-72.
4) For those states (27%) which do have hydrocarbon regulations, their emission regulation is equal to E_s, ref 84, p. 69-72
5) 41% of ink used in an average metal decorating plant is solvent and is emitted to the atmosphere. (ref 249, p. 155)
6) 50% of all metal decorating plants operate under L.A. rule 66. (ref 050, p. 8)

$$E_{\substack{\text{All States}\\ \text{N.Y., Ill., PA, Calif.}}} = \frac{(41 \text{ lbs hydrocarbons})(2000 \frac{\text{lbs}}{\text{Ton}})}{100 \text{ lbs Ink Used}} \times .15 = 123 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}$$

$$E_{\substack{\text{Metal}\\ \text{Decorating}}} = .50(123 \tfrac{\text{lbs}}{\text{Ton}}) + .50\left[(.27)(E_s) + .73(3700 \tfrac{\text{lbs}}{\text{Ton}})\right]$$

$$E_{\substack{\text{Metal}\\ \text{Decorating}}} = 61.5 + .135 E_s + 3701 = \frac{61.5 + 3701}{.865} = 3193 \tfrac{\text{lbs}}{\text{Ton}}$$

$$\boxed{E_{\substack{\text{Metal}\\ \text{Decorating}}} = 3200 \frac{\text{lbs hydrocarbons}}{\text{Ton Ink Used}}}$$

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/3/75

Source Graphic Arts

For determination of E_s for lithography we only considered emissions from web offset type of printing operations.

Ref 050 p. 5 gives a range of emission rates from web offset dryer exhausts. The average for a 2 color operation is 6.1 lbs/hr. The average for a 4 color operation is 14.5 lbs/hr. We assume the average emission rate for all web offset operations to be the average of these two values:

$$\text{Average Emission} = \frac{6.1+14.5}{2} = 10.3 \frac{\text{lbs hydrocarbons}}{\text{hr.}}$$

Ref 050, p. 8 gives the average % solvent in lithographic ink coating as 35%. Assuming the 10.3 $\frac{\text{lbs}}{\text{hr}}$ results entirely from the solvent the following calculation can be made:

$$\text{Avg.} \frac{\text{TONS INK USED}}{\text{HR}} = \frac{10.3 \frac{\text{lbs}}{\text{hr}}}{(.35)(2000 \frac{\text{lbs}}{\text{ton}})} = .015 \frac{\text{TONS}}{\text{HR}}$$

85% reduction of 10.3 $\frac{\text{lbs}}{\text{hr}}$ gives an emission rate of 1.5 lbs/hr. This is below 3 lb/hr so for those states which have enacted L.A. rule 66, the applicable regulation is 3 lbs/hr.

In order to compute E_s for lithography we make the following additional assumption:

1) 50% of all plants using lithographic printing operate under L.A. Rule 66.
2) For the states which do not have hydrocarbon regulations (13%) $E_s = E_u$.
3) For the states which do have hydrocarbon regulations (87%), their emission regulation is equal to E_s.

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Computation Sheet For Emission Factors

Calculations Done By K. Tower Date 1/3/75

Source Graphic Arts

$$E_{5\,\text{Lithography}} = .50\left(\frac{3\,\frac{\text{lbs.}}{\text{hr}}}{.015\,\frac{\text{Tons}}{\text{Hr.}}}\right) + .50\left[.27(E_5) + .73\left(2800\,\frac{\text{lbs}}{\text{Ton}}\right)\right]$$

$$= 100\,\frac{\text{lbs}}{\text{Ton}} + .135E_5 + 2044\,\frac{\text{lbs}}{\text{Ton}}$$

$$= \frac{2144\,\frac{\text{lbs}}{\text{Ton}}}{.865} = 2478\,\frac{\text{lbs}}{\text{Ton}}$$

$$\boxed{E_{5\,\text{Lithography}} = 2500\,\frac{\text{lbs hydrocarbons}}{\text{Ton Ink used}}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By ______________________ Date 9/02/74

Source Petroleum Storage & Transfer — Transfer

Ref (24) p.III-38 indicates the following breakdown for methods of crude oil transfer to refineries.

75.2% - Pipeline
23.0% - Water (barges)
1.8% - Tank cars & trucks

Although there are emissions inherent in pipeline transfer, they will not quantified as part of this study.

Reference is made to "Industrial Factors" calculation sheet for "Petroleum Storage and Transfer - Tanks" for much of the info for this transfer analysis.

Crude Oil

1968 Crude oil throughput = 4.3×10⁹ gals

[illegible]

Growth (R) is assumed to be the same as that for "total liquid hydrocarbons" Ref (19) 229, 3030A

$$R_{crude} = \sqrt[11]{\frac{1971}{1960}} - 1.0 = \sqrt[11]{\frac{5600}{3550}} - 1$$

$$\boxed{R_{crude} = 4.22\%}$$ mpd

The "K" factor will be determined from the ratio of refinery production to capacity.

$$K = \frac{11\times10^6}{13\times10^6} = 0.85 \qquad \boxed{K = 0.85}$$

Ref (24) p.III-29

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/13/74

Source Petroleum S&T - Transfer

$$A_{\text{total crude}} = \frac{(3.8\times10^{9}\ \text{bbls})(1.0428)^{7}}{0.85} = 5.97\times10^{9}\ \text{bbls}$$

However, only 23.0% + 1.2% is handled by water or tanker.

Since no information could be found regarding the modes (and %'s) of transport of finished products from the refinery, marine & tanker transport will be treated together as non-pipeline transfer.

$$A_{\text{crude transfer}} = (5.97\times10^{9})(.242) = 1.44\times10^{9}$$

$$\boxed{A_{\text{crude transfer}} = 1.44\times10^{9}\ \text{bbls}}$$

No direct information could be located regarding what fraction of finished petroleum products are transported by pipeline. The following analysis presents an estimation for the purpose of this study.

① Bulk stations have capacities less than 2,000,000 gals generally (Ref [illegible] p.II-47) & the petroleum products delivered to these tanks come via tanker, truck or boat (Ref [illegible] p.4-9, Fig 4-6).

② Terminals have capacities greater than 2,000,000 gals generally (Ref [illegible] p.II-47) & the petroleum products are delivered to the tanks by pipeline (Ref [illegible] p.4-9, Fig 4-6)

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Computation Sheet For Industrial Factors

Calculations Done By Hanna Date 9/17/74

Source Petroleum Storage & Transfer - Tankage

Ref ([illegible]) p.III-45 TAB III-21 INDICATES A THROUGHPUT OF

$$204 \times 10^6 \times 10 = 2.04 \times 10^9 \text{ BBLS GASOLINE}$$

$$\frac{2{,}000{,}000 \text{ GALS}}{42 \frac{\text{GAL}}{\text{BBL}}} = 47{,}619 \text{ BBLS}$$

The throughput for tanks of 50,000 BBLS OR LESS CAN BE DET'D FROM DATA ON TAB III-21

$$(1965 \text{ TANKS})\left(200{,}000 \frac{\text{BBL}}{\text{TANK}}\right) + (1143 \text{ TANKS})\left(400{,}000 \frac{\text{BBLS}}{\text{TANK}}\right) + \frac{(762 \text{ TANKS})\left(600{,}000 \frac{\text{BBLS}}{\text{TANK}}\right)}{2} = .393\times10^9 + .457\times10^9 + .229\times10^9$$

$$= 1.079 \times 10^9 \text{ BBLS}$$

OF 2.04×10^9 BBLS OF GASOLINE, 1.079×10^9 BBLS ARE ROUTED THRU TANKS LESS THAN 50,000 BBLS.

$\therefore \frac{1.079}{2.04} = 53\%$ of the gasoline handled goes thru TANKS LESS THAN 50,000 BBL CAPACITY OR BULK STATIONS. The REMAINDER (47%) is, therefore, ROUTED to TERMINALS (BY PIPELINE)

For the analysis, we will assume that all the petroleum products are similarly routed.

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/18/84

Source Petroleum S/T - Transfer

Motor Gasoline

$$A_{\frac{gas}{yr}} = \frac{123.9 \times 10^9 \text{ gals}}{42 \frac{\text{gals}}{\text{bbl}}} = 2.95 \times 10^9 \text{ bbls}$$

As previously determined, 53% is handled by truck tankage and boat. So, the value of 'A' for non-pipeline transport is

$$A_{\frac{gas}{yr}} = (2.95 \times 10^9 \text{ bbls})(.53) = 1.56 \times 10^9$$

$$\boxed{A_{\frac{gasoline}{yr}} = 1.56 \times 10^9 \text{ bbls}}$$

Also, determined previously,

$$\boxed{k' = 0.85}$$

$$\boxed{P_{e_{gas}} = 3.46 \text{ lb}}$$ [illegible]

Aviation Gas

$$A_{\frac{avgas}{yr}} = \frac{2.82 \times 10^9 \text{ gals}}{42 \frac{\text{gal}}{\text{bbl}}} = 67.1 \times 10^6 \text{ bbl}$$

$$A = 67.1 \times 10^6 (.53) = 35.6 \times 10^6 \text{ bbl}$$

$$\boxed{A_{\frac{avgas}{yr}} = 35.6 \times 10^6 \text{ bbl}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Date 9/18/79

Source Petroleum S&T – [illegible]

As determined previously,

$$\boxed{K = 0.85}$$

$$\boxed{P_{[illegible]} = 9.4\%}$$ [illegible]

Special Naphtha

$$A = \frac{1.4 \times 10^{9}\ \text{gals}}{42\ \frac{\text{gal}}{\text{bbl}}} \times .53 = 17.7 \times 10^{6}\ \text{bbls}$$

$$\boxed{A = 17.7 \times 10^{6}\ \text{bbls}}$$

As determined previously,

$$\boxed{K = 0.85}$$

$$\boxed{P_{[illegible]} = 0.7\%}$$ [illegible]

Jet Fuel

$$A_{\text{jet fuel}} = \frac{11.6 \times 10^{9}\ \text{gals}}{42\ \frac{\text{gal}}{\text{bbl}}} \times .53 = 146 \times 10^{6}\ \text{bbls}$$

$$\boxed{A_{\text{jet fuel}} = 146 \times 10^{6}\ \text{bbls}}$$

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/18/79

Source Petroleum S/T - [illegible]

As previously calc'd

$$\boxed{K = 0.85}$$

$$\boxed{P_{C_{\text{fuel}}} = 94\%}$$ [illegible]

Kerosene distillate fuel oil will not be analyzed due to their low vapor pressures.

P_d 10/11/79

For crude transfer:

Data on % of crude oil gives breakdown as follows
75.8% (pipeline) ← not applicable to this study
23.0% (marine)
1.2% (Tank cars & trucks)

From ref (37) p.29

IRS depreciation guideline = 6 yrs for tank cars trucks [illegible]

Assume twice = 12 yrs

IRS depreciation guideline = 18 yrs for vessels, barges, tugs

Assume twice = 36 yrs

$$P_d = \frac{1}{\left(\frac{23}{24.2}\right)(36) + \left(\frac{1.2}{24.2}\right)(12)} = \frac{1}{34.21 + .60} = 0.029$$

$$\boxed{P_{d_{\text{crude}}} = 0.029}$$

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Computation Sheet for Industrial Factors

Calculations Done By [illegible] Date 10/11/79

Source Breakdown S&T - Transfer

For all other fluids, we have no % breakdown as to transfer by marine or land conveyance. Assume, therefore 50/50.

Same eq'n as p 6 of these calc's

$$P_B = \frac{1}{36(.5) + 12(.5)} = \frac{1}{18+6} = \frac{1}{24}$$

$$\boxed{P_{B_{\text{all other fluids}}} = 4.17\% = .0417}$$

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Computation Sheet For Emission Factors

Calculations Done By Moore Date 9/22/78

Source Petroleum Storage & Transfer – Transfer

Since we are dealing with transfer, working losses will be the major source of emissions. It is recognized that there will be some breathing losses during transit but these are considered to be negligible.

Eu & En for working losses for the levels of control have been previously determined for storage tanks. We will assume that tank cars, trucks & marine vessels are "portable storage tanks" and, therefore, subject to the same emissions.

Summary:

lb/Tgal

	Eu	En
✓ Motor Gasoline	0.116	0.0116
Crude Oil	0.084	0.048
✓ Aviation Gas	0.116	0.055
✓ Special Naphtha	0.116	0.056
✓ Jet Fuel	0.116	0.054

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/6/78

Source Petroleum S&T - Transfer

$\underline{E_2}$

Use same assumptions & approaches used for "Petroleum Storage & Transfer - Tanks" Emission Factors

$$E_{S_{\substack{GAS\\DIST}}} = \left(\frac{2}{31}\right)(.076) + \left(\frac{29}{31}\right)(.116) = .005 + .066 = .071$$

$$\boxed{E_{S_{\substack{GASOLINE\\DIST\\TANK}}} = 0.071\ \#/BBL}$$

$$E_{S_{\substack{AVGAS\\DIST}}} = \left(\frac{13}{31}\right)(.055) + \left(\frac{18}{31}\right)(.116) = .0237 + .066$$

$$\boxed{E_{S_{\substack{AVGAS\\DIST\\TANK}}} = 0.090\ \#/BBL}$$

$$E_{S_{SP.WA}} = \left(\frac{13}{31}\right)(.036) + \left(\frac{18}{31}\right)(.116)$$

$$\boxed{E_{S_{\substack{SP.WA\\DIST\\TANK}}} = 0.09\ \#/BBL}$$

$$\boxed{E_{S_{\substack{JETFUEL\\DIST\\TANK}}} = 0.09\ \#/BBL}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/11/84

Source [illegible] S.I.T. - [illegible]

$$E_S = \left(\frac{14}{41}\right)(.048) + \left(\frac{27}{41}\right)(.084)$$

$$\boxed{E_S = 0.071 \ \#/\text{gal.}}$$

Summary of E_S: #/gal

	EXISTING	NEW
Gasoline	.071	.016
Crude	.071	.048
Av Gas	.090	.055
Sp. Nap.	.090	.056
Jet Fuel	.090	.054

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/18/74

Source Petroleum Storage & Transfer - Marketing

Values of K, A, R have been determined for gasoline in previous calculations by TRC for this study. They are summarized below

$A = 2.95 \times 10^9$ gals

$K = 0.85$

$R_{gas} = 3.46\%$ cmpd

This P_c is based on the following assumptions:

(1) Automobile gas mileage remains constant between 1975 & 1985
(2) number of miles driven per year per car remains constant between 1975 & 1985

These assumptions are, however, subject to the uncertainties of the energy crisis, auto mfg & state of the economy.

P_B Ref (37) p.89 Depreciation for autos = 3 yrs
Assume twice the IRS allowable = 6 yrs

(6 yrs)(10,000 mi/yr) = 60,000 mi $P_B = \frac{1}{6} = 0.167$

$P_B = 0.167$

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Computation Sheet For Emission Factors

Calculations Done By Hoover Date 9/18/84

Source Petroleum Storage & Transfer – Refueling

Ref (71) p 4.4-2 Table 4.4-1 states

$$E_U = 12 \frac{lb}{10^3 gal}$$

$$(0.012)\left(42 \frac{gal}{BBL}\right) = 0.304\ lb/BBL$$

$$\boxed{E_U = 0.504\ lb/BBL}$$

Ref (87) p 26

Overall efficiencies of 85% can be expected from good vapor collection & recovery systems.

$$E_N = 0.504(.15) =$$

$$\boxed{E_N = 0.0756\ lb/BBL}$$

There are no state regs for automobile refueling 10/11/84

$$\therefore E_S = E_U = .504$$

$$\boxed{E_{S_{exist}} = 0.504 \frac{lb}{BBL}}$$

$$\boxed{E_{S_{new}} = 0.0756 \frac{lb}{BBL}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Nuzzo Date 9/18/74

Source Petroleum Storage & Transfer - Service Stations

Ref ㉞ p III-40 shows 1968 gasoline throughput of 83x10^9 gals

Values of K & R have been previously determined to be

$$\boxed{K = 0.85}$$

$$\boxed{R_{gasoline} = 3.46\%} \text{ cmpd}$$

"Industrial Factors" calculation sheet for "Petroleum Storage & Transfer - Tanks"

$$A = \left(\frac{83 \times 10^9 \text{ gals}}{42 \frac{\text{gal}}{\text{bbl}}}\right)(1.0346)^7\left(\frac{1}{0.85}\right) = 2.95 \times 10^9 \text{ bbl}$$

$$\boxed{A_{gasoline} = 2.95 \times 10^9 \text{ BBLS}}$$

Ref 37 p 31

IRS depreciation guideline = 16 yrs
Use twice the guideline = 32 yrs

$$P_B = 1/32$$

$$\boxed{P_B = 0.031}$$

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Project Number - 37391 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By [illegible] Date 9/18/74

Source Petroleum Storage & Transfer - Service Stations

Ref ⑺ p 4.4-2 TAB 4.4-1

$E_U = 9 \frac{lb}{1000 gal}$ (For 50/50 breakdown of splash, submerged fill)

$0.009 \frac{lb}{gal} \times \frac{42 gal}{BBL} = 0.378 \ lb/BBL$

$\boxed{E_U = 0.378 \ lb/BBL}$

Ref ⑺ p 4.4-2 TAB 4.4-1 states

$E_N = 0.8 \ lb/1000 gal$ with vapor return systems

$\left(0.0008 \frac{lb}{gal}\right)\left(42 \frac{gal}{BBL}\right) = 0.0336 \ lb/BBL$

R = 91%

$\boxed{E_N = 0.0336 \ lb/BBL}$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date [illegible]

Source Petroleum Storage & Transfer – Service Stations

Deriv of E_S: Use same ref's & assumptions used for "Petroleum Storage & Transfer – Tanks" Emission Factors

$$E_S = \left(\frac{26}{57}\right)(.0336) + \left(\frac{31}{57}\right)(.378) = .0195 + .0117$$

$$\boxed{E_{S_{[illegible]}} = 0.229 \ \frac{lb}{BBL}}$$

$$\boxed{E_{S_{[illegible]}} = 0.034 \ \frac{lb}{BBL}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By ______________ Date 9/13/74

Source Petroleum Storage & Transfer - Tanks

PETROLEUM PRODUCTS ARE STORED IN TANKS OF VARIOUS SIZES & AT VARIOUS LOCATIONS ALONG THEIR PATH OF DISTRIBUTION. OUR ANALYSIS WILL COVER THE STORAGE OF THE FOLLOWING PETROLEUM PRODUCTS:

(1) [illegible] PETROLEUM
(2) MOTOR GASOLINE
(3) AVIATION GASOLINE
(4) SPECIAL NAPHTHA
(5) JET FUEL (NAPHTHA & KEROSENE)
(6) KEROSENE
(7) DISTILLATE FUEL OIL

RESIDUAL FUEL OIL WILL NOT BE INCLUDED DUE TO ITS LOW VAPOR PRESSURE.

OUR ANALYSIS WILL COVER THE STORAGE OF THESE PRODUCTS AT
(1) THE REFINERY
(2) BULK STATIONS & TERMINALS

The major ref for this work is (74). Unless otherwise specified only page & table numbers will be quoted.

THE FOLLOWING TABLE SUMMARIZES INFO FROM REF (74)

PRODUCT	1968 [illegible]	1968 [illegible]	[illegible]
MOTOR GASOLINE	[illegible]	[illegible]	83
CRUDE OIL	137	[illegible] ⑧	[illegible]
AV GAS	14.0	6.6	1.26
SP. NAPHTHA	[illegible]	[illegible]	1.134
JET FUEL	42.6	17.9	6.31
KEROSENE	76.3	39.6	—
DIST. FUEL OIL	346.2	169.5	—

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Computation Sheet For Industrial Factors

Calculations Done By Hogan Date 9/13/74

Source Petroleum Storage & Transfer - Tanks

(1) x 10^6 BBL.
(2) x 10^9 GAL.
(3) p.III-43
(4) BASED ON REF (14) p III-37

(6) REF (79) p III-37
(7) " " p III-38
(3040 x 10^6)(11)(42) = 166 x 10^9 gal.

THROUGHPUT TO CAPACITY RATIO FOR FIGURE OF 11

THROUGHPUT = 3.8 x 10^9 BBLS

= 160 x 10^9 gals

(5) p III-40 ff TAB. III-24, 25

We will use REF (79) EQ. 3020 A, B TO DETERMINE GROWTH RATES. DATA REFLECTS CONSUMPTION. WE WILL ASSUME THAT CAPACITY & THROUGHPUT INCREASE @ THE SAME RATE AS CONSUMPTION INCREASES.

(1) Motor gasoline - REF (79) EQ. 3020A

$$R_{gas} = \sqrt[14]{\frac{1974}{1960}} - 1.0 = \sqrt[14]{\frac{2515.2}{1534.7}} - 1.0 = 3.46\%$$

$R_{gasoline} = 3.46\%$ compound

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/13/74

Source Petroleum Storage & Transfer - Tanks

(2) Distillate fuel oil -- steady growth per ref ⑬ p 229, 302A

$$P_c = \sqrt[11]{\frac{1971}{1960}} - 1.0 = \sqrt[11]{\frac{371.2}{265.3}} - 1.0 = 3.2\%$$

$$\boxed{P_{c_{\text{distillate oil}}} = 3.2\%} \text{ cmpd}$$

(3) Kerosene

$$P_{c_{\text{ker}}} \approx 0 \qquad \text{Ref ⑬ } 229, 302A$$

(4) Jet fuel

$$P_c = \sqrt[11]{\frac{1971}{1960}} - 1.0 = \sqrt[11]{\frac{342.7}{134.2}} - 1.0 = 9.1\%$$

$$\boxed{P_{c_{\text{jet fuel}}} = 9.1\%} \text{ cmpd}$$

(5) Special naphtha

Ref ⑬ 229, 302A

$$P_c = \sqrt[11]{\frac{1971}{1960}} - 1.0 = \sqrt[11]{\frac{30.1}{27.6}} - 1.0 = \boxed{.7\% = P_{c_{\text{special naphtha}}}} \text{ cmpd}$$

(6) No data on aviation gas - assume to be same as jet fuel

$$\boxed{P_{c_{\text{av gas}}} = 9.1\%} \text{ cmpd}$$

(7) Crude oil

Assume growth to be the same as that for "total liquid hydrocarbons". Ref ⑬ 229, 302A

$$P_{c_{\text{crude}}} = \sqrt[11]{\frac{1971}{1960}} - 1.0 = \sqrt[11]{\frac{[illegible]}{[illegible]}} - 1.0 = 4.22\%$$

$$\boxed{P_{c_{\text{crude}}} = 4.22\%} \text{ cmpd}$$

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/13/74

Source Petroleum Storage & Transfer - Tanks

Determination of 1975 Capacities & Throughput

Assume that capacity & throughput grow @ the same rate.

(1) Gasoline

$$A_{\substack{gas \\ cap}} = (\underset{\substack{\times 10^6 \\ BBLS}}{375.7})(1.0346)^7 = 476.7 \times 10^6 \text{ BBLS}$$

$$\boxed{A_{\substack{gasoline \\ capacity}} = 476.7 \times 10^6 \text{ BBLS}}$$

$$A_{\substack{gas \\ TP}} = (83 \times 10^9 \text{ gals})(1.0346)^7 = 105.3 \times 10^9 \text{ gals}$$

$$\boxed{A_{\substack{gasoline \\ TP}} = 105.3 \times 10^9 \text{ gals}} \leftarrow \text{PRODUCTION, NOT CAPACITY/ SEE P7}$$

(2) Distillate Fuel Oil

$$A_{\substack{oil \\ cap}} = (515.7 \times 10^6)(1.032)^7 = 642.9$$

$$\boxed{A_{\substack{oil \\ cap}} = 642.9 \times 10^6 \text{ BBLS}}$$

(3) Kerosine

$$\boxed{A_{\substack{kerosine \\ cap}} = 75.8 \times 10^6 \text{ BBLS}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Moore Date 9/13/79

Source Petroleum Storage/Terminals - TANKS

(4) JET FUEL

$$A_{\substack{JET\\CAP}} = \underset{\text{Ton}}{(66)}(1.094)^7 = 123.8 \times 10^6$$

$$\boxed{A_{\substack{JET\\CAP}} = 123.8 \times 10^6 \text{ BBLS}}$$

$$A_{\substack{JET\\TP}} = (5.31 \times 10^9)(1.094)^7 = 9.9 \times 10^9 \text{ gals}$$

$$\boxed{A'_{\substack{JET\\TP}} = 9.9 \times 10^9 \text{ gals}} \longleftarrow \text{PRODUCTION NOT CAPACITY SEE P7}$$

(5) SPECIAL Naphtha

$$A_{\substack{SP.NA\\CAP}} = (17.3 \times 10^6)(1.007)^7 = 18.2 \times 10^6$$

$$\boxed{A_{\substack{SP.NAP.\\CAP}} = 18.2 \times 10^6 \text{ BBL}}$$

$$A_{\substack{SP.NAP\\TP}} = (1.134 \times 10^9)(1.007)^7 = 1.19 \times 10^9$$

$$\boxed{A'_{\substack{SP.NAP\\TP}} = 1.19 \times 10^9 \text{ gals}} \longleftarrow \text{PRODUCTION NOT CAPACITY SEE P7}$$

(6) AVIATION GAS

$$A_{\substack{AVGAS\\CAP}} = (19.8 \times 10^6)(1.094)^7 = 37.1 \times 10^6$$

$$\boxed{A_{\substack{AVGAS\\CAP}} = 37.1 \times 10^6 \text{ BBL}}$$

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Computation Sheet For: Industrial Factors

Calculations Done By [illegible] Date 9/12/74

Source Petroleum Storage & Transfer — Tanks

$$A_{\text{avgas}_{TP}} = (1.22\times10^9)(1.094)^7 = 2.40\times10^9$$

$$\boxed{A_{\text{avgas}_{TP}} = 2.40\times10^9 \text{ gals}}$$ ← PRODUCTION NOT CAPACITY SEE p 7

(4) CRUDE OIL

$$A_{\text{crude}_{CAP}} = [illegible]\,(1.0422)^7 = [illegible]\times10^6$$

$$\boxed{A_{\text{crude}_{CAP}} = [illegible]\times10^6 \text{ GALS}}$$

$$A'_{\text{crude}_{TP}} = (160\times10^9)(1.0422)^7$$

$$\boxed{A'_{\text{crude}_{TP}} = 214\times10^9 \text{ gals}}$$

Ref ⑭ p III-53

"Approximately 70% of U.S. crude oil is produced in the states of and offshore of Texas, Louisiana and California."

Storage losses can occur by two mechanisms
① Breathing losses
② Working losses

Breathing losses are a function of tank outage, size, color, MET conditions, etc. A 'K' value must be equal to unity for the model & where since storage is a static not dynamic condition.

Working losses, on the other hand represent a dynamic situation where a 'K' factor can actually be determined. Throughput, the occurrence which results in working losses, can be considered as production. Maximum refinery capacity could be considered as maximum throughput capacity.

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/16/74

Source Petroleum Storage & Transfer

For refineries, $K' = \frac{\text{Production}}{\text{Capacity}} = \frac{11 \times 10^6}{13 \times 10^6} = 0.85$

Ref (57) p III-29

$K'_{\substack{\text{refinery}\\ \text{losses}}} = 0.85$

$K'_{\substack{\text{marketing}\\ \text{losses}}} = 1.0$

All "A" values previously calculated for throughput must be divided by 0.85 to get capacity.

$A_{\substack{gas\\ TP}} = \frac{105.3 \times 10^9}{0.85} =$

$A_{\substack{gasoline\\ TP}} = 123.9 \times 10^9$ gals ✓ $(2.95 \times 10^9$ bbls$)$

$A_{\substack{jet\,fuel\\ TP}} = \frac{9.9 \times 10^9}{0.85} = 11.6 \times 10^9$

$A_{\substack{jet\,fuel\\ TP}} = 11.6 \times 10^9$ gals $(276 \times 10^6$ bbls$)$

$A_{\substack{sp.nap\\ TP}} = \frac{1.19 \times 10^9}{.85} = 1.4 \times 10^9$

$A_{\substack{sp.nap.\\ TP}} = 1.4 \times 10^9$ gals $(33.3 \times 10^6$ bbls$)$

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 9/16/79

Source Petroleum Storage & Transfer - Tanks

$A_{\text{avgas},\,TP} = \frac{2.51\times10^9}{.89} = 2.82\times10^9$ gals

$\boxed{A_{\text{AV GAS},\,TP} = 2.82\times10^9 \text{ GALS}}$ ✓ $\left(67.1\times10^6 \text{ BBLS}\right)$

$A_{\text{crude},\,TP} = \frac{224\times10^9}{.89} = 252\times10^9$

$\boxed{A_{\text{crude},\,TP} = 252\times10^9 \text{ GALS}}$ ✓ $\left(6.00\times10^9 \text{ BBLS}\right)$

P_a Ref ㊲ p 31

IRS guideline for storage tanks = 16 yrs
Assume twice the guideline = 32 yrs

$P_a = \frac{1}{32}$

$\boxed{P_a = 0.031}$ All tanks

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 3/26/78

Source Petroleum Storage & Transfer

Gasoline

Ref (74) p. II-81

For breathing losses:

(a) 25% fixed roof tanks @ 0.4 lb/day/1000 gal

(b) 75% floating roof tanks @ 4.8 lb/day/1000 bbls

For working losses:

(c) 11 lb/1000 gal

@ 42 gal/bbl

$$\left[(4.8)(.75)+(0.4)(.25)(42)\right] \times 365 \frac{\text{days}}{\text{yr}} \times \frac{1}{1000} \times 1\text{ yr} =$$

$$\frac{\text{lb}}{\text{day bbl}}$$

$$E_U = 2.85 \frac{\text{lb}}{\text{bbl}}$$

$$\boxed{E_{U_{\text{gas breathing}}} = 2.85 \frac{\text{lb}}{\text{bbl}}}$$

$$E_{U_{\text{gas work}}} = .011 \frac{\text{lb}}{\text{gal}} \times \frac{42\text{ gal}}{\text{bbl}} = 0.462 \frac{\text{lb}}{\text{bbl}}$$

However, there are essentially no working losses from floating roof tanks

$$E_U = 0.462(.25) + 0(.75) = .116$$

$$\boxed{E_{U_{\text{gas working}}} = 0.116 \frac{\text{lb}}{\text{bbl}}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date [illegible]

Source Petroleum - Tanks

Aviation gas - same as gasoline

$$\boxed{E_{W_{\text{avgas, breath.}}} = 2.25 \text{ lb/gal}}$$

$$\boxed{E_{W_{\text{avgas, WR}}} = 0.116 \text{ lb/gal}}$$

Special Naphthas - same as gasoline

$$\boxed{E_{W_{\text{sp. nap., breath}}} = 2.25 \text{ lb/gal}}$$

$$\boxed{E_{W_{\text{avgas, WR}}} = 0.116 \text{ lb/gal}}$$

Jet Fuel

Both naphtha & kerosene are used as jet fuel.

Ref (14) p III-52 gives breakdown & emission factors

$\frac{23.9}{23.9+42.1} = 36$ % nap. — $0.4 \frac{\text{lb}}{\text{day}\cdot 1000\text{ gal}}$ - fixed (25%); $4.8 \frac{\text{lb}}{\text{day}\cdot 1000\text{ gal}}$ - floating (75%)

$\frac{42.1}{23.9+42.1} = 64$ % ker. — $1.7 \frac{\text{lb}}{\text{day}\cdot 1000\text{ gal}}$ - fixed (25%); $1.6 \frac{\text{lb}}{\text{day}\cdot 1000\text{ gal}}$ - floating (75%)

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Computation Sheet For Emission Factors

Calculations Done By ________ Date 9/15/74

Source Petroleum - Tanks

$$E_u = \left\{(.36)\left[(6.4)(.25)(.42)+(4.8)(.75)\right] + (.64)\left[1.7(.25)+1.6(.75)\right]\right\}\frac{\times 365}{1000}$$

$$= \left\{(.36)\left[4.2+3.6\right] + (.64)\left[.425+1.2\right]\right\}\frac{\times 365}{1000}$$

$$\frac{365}{1000}(2.808+1.04) = 1.40$$

$$\boxed{E_{u_{\substack{\text{jet fuel}\\ \text{gasoline}}}} = 1.40\ \frac{\#}{\text{gal}}}$$

$E_{u_{\substack{\text{jet fuel}\\ \text{w/w}}}}$ is same as gasoline Ref ㊹
for naphtha p III-92

$E_{u_{\text{w/w}}}$ for kerosine as jet fuel = 0

$E_J = (0.116)$

Since value of throughput was for naphtha only

$$\boxed{E_{u_{\substack{\text{jet fuel}\\ \text{w/w}}}} = 0.116\ \#/\text{gal}}$$

Kerosine

1.7 #/day·1000gal - 25%
1.6 #/day·1000gal - 75%

$$E_{u_{\text{kerosine}}} = 365\left[\frac{(1.7)(.25)+1.6(.75)}{1000}\right] = \left(\frac{.425+1.2}{1000}\right)365 = 0.593\ \#/\text{gal}$$

$$\boxed{E_{u_{\substack{\text{kerosine}\\ \text{breathing}}}} = 0.593\ \#/\text{gal}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 9/11/78 ✓

Source Petroleum - Terminals

$Eu_{\text{kerosene, new}} = 0$

Vapor pressure too low to be considered
Ref (24) p. III-23

Distillate oil - same as kerosene " " "

$Eu_{\text{dist. oil, existing}} = 0.593\ g/gal$

$Eu_{\text{dist. oil, new}} = 0$

Crude oil

(a) @ terminals, etc. Ref (24) p. III-38

Assuming losses:

$$\frac{(1135.7 + 1878.6)(\times 10^3)(365)}{304 \times 10^6} = 2.38\ \frac{g}{gal}$$

(b) @ refinery

$$\frac{(1511.2 + 910)(10^3)(365)}{137 \times 10^6} = 3.99\ g/gal$$

$\frac{137}{137+304} = 31\ \%$ @ refinery

$\frac{304}{137+304} = 69\ \%$ @ terminals, etc.

$Eu_{\text{crude, existing}} = \overset{1.237}{3.99(.31)} + \overset{1.642}{2.38(.69)}$

$Eu_{\text{crude, existing}} = 2.879\ g/gal$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 9/18/84

Source Petroleum Storage [illegible] - Tanks

Working losses

Ref (74) p III-40

$E_w = 8.0$ lb/1000 gal

$$\frac{(8.0)(42)}{1000} = 0.336 \text{ lb/bbl}$$

Since there are no working losses when heating [illegible] tanks,

$$E_w = (0.336)(.25) + (.75)(0) = 0.084$$

$$\boxed{E_{w_{\text{overall working}}} = 0.084 \text{ lb/bbl}}$$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 9/12/78

Source Petroleum Storage & Transfer - Tanks

The following table outlines the potential % control achieved on HC emissions from storage tanks. Ref ⑬ TAB 1 pg-7

	Refinery	Terminal
Gasoline	90% ①	90% ①
Crude	60% - 70% ②	30% - 40% ②
AV GAS		
JP NAP.		
JET/KER.		
RESID		
Dist. oil		30 - 40% ②

① Vapor Recovery
② Floating Roof

Since no additional, pertinent info could be located, we will assume refinery control for the remaining fluids to be the same as for crude & terminal control for the remaining fluids to be the same as for crude oil & distillate oil.

Motor Gasoline

Since η = 90% @ the refinery and the terminal, there is no need to provide the "[illegible]" emission factors.

$e_{HC_B} = 0.1(2.84) = 0.284$

$e_{HC_W} = 0.1(0.116) = 0.0116$

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Computation Sheet For Emission Factors

Calculations Done By ______________ Date 9/2/84

Source Petroleum S&T - Tanks

$\boxed{EN_{\text{gas breathing}} = 0.225}$ #/bbl

$\boxed{EN_{\text{gas WH}} = 0.016 \text{ \#/bbl}}$

Crude oil

Assume avg ordinary control = 60%
Assume avg terminal control = 35%

Ref & p1 of "Emission Factors" calc. sheet for breathing losses

$\frac{137}{137+304} = 31$ % ordinary @ ref (breathing losses)

$\frac{304}{137+304} = 6$[illegible] % " @ terminal (" ")

$\frac{173}{173+166} = 51$ % throughput @ ref (working losses)

$\frac{166}{173+166} = 49$ % " @ terminal (" ")

see p 4 of these calcs

$EN_{\text{crude breathing}} = (0.31)(1-.6)(3.99) + (.69)(1-.35)(2.33)$

$= 0.495 + 1.047 = 1.562$

$\boxed{EN_{\text{crude breathing}} = 1.56 \text{ \#/bbl}}$

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Computation Sheet For Emission Factors

Calculations Done By Horner Date 9/17/74

Source Petroleum S&T - Tanks

$$E_{N\,\text{crude},\,WH} = (0.31)(1-.6)(.084) + (.69)(1-.35)(.084)$$

$$= .0104 + .0377 = .0481$$

$$\boxed{E_{N\,\text{crude},\,WH} = 0.0481\ \#/\text{gal}}$$

AVIATION GAS

Assume $\eta = 60\%$ @ refinery
$\eta = 35\%$ @ terminals

Refer to "Evaporative Factors" calc. sheet for following values (Pi)

$\frac{140}{140+58} = .71$ % cap @ ref.

$\frac{58}{140+58} = .29$ % cap @ term.

$$E_{N\,\text{avgas},\,\text{breath}} = (.71)(1-.6)(2.85) + (.29)(1-.35)(2.85)$$

$$= 0.809 + .537 = 1.346$$

$$\boxed{E_{N\,\text{avgas},\,\text{breath}} = 1.35\ \#/\text{gal}}$$

$$E_{N\,\text{avgas},\,WH} = (.71)(1-.6)(0.116) + (.29)(1-.35)(0.116)$$

$$= .0329 + .0219 = .0548$$

$$\boxed{E_{N\,\text{avgas},\,WH} = 0.0548\ \#/\text{gal}}$$

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Computation Sheet For Emission Factors

Calculations Done By ______________________ Date 9/17/74

Source Roseburg 5.15 – Dallas

Special Naphthas

$\eta = 60\%$ @ refinery
$\eta = 35\%$ @ terminals

$\frac{11.6}{11.6+5.7} = 67$ % cap @ ref.

$\frac{5.7}{11.6+5.7} = 33$ % cap @ term.

$E_{shipping, NAP} = (.67)(.4)(.116) + (.33)(.65)(.116) = .0311 + .0249 = .056$

$\boxed{E_{shipping, NAP} = 0.056 \ \#/bbl}$

$E_{N\ storage,\ ref.} = (.67)(1-.6)(0.85) + (.33)(1-.35)(0.85)$
$= 0.264 + .537 = 130$

$\boxed{E_{N\ storage,\ breathing} = 130 \ \#/bbl}$

Jet Fuel

$\eta = 60\%$ @ refinery
$\eta = 35\%$ @ terminals

} This assumes that the vapor pressure of jet fuel is sufficiently high to qualify it for NSPS (existing)

$\frac{48.6}{48.6+17.4} = 74$ % cap @ ref.

$\frac{17.4}{48.6+17.4} = 26$ % cap @ term.

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 9/13/84

Source [illegible] S/T - Tanks

$E_{N_{jet,\,Ex.}} = (.74)(1-.6)(1.40) + (.26)(1-.35)(1.40)$

$= .4144 + .2366 = .651$

$\boxed{E_{N_{jet\ fuel,\ existing}} = 0.651\ \#/gal}$

$E_{N_{jet,\,NS}} = (.74)(.4)(0.116) + (.26)(.65)(0.116)$

$= 0.0343 + .0196 = .0539$

$\boxed{E_{N_{jet\ fuel,\ NS}} = 0.0539\ \#/gal}$

Kerosene

$\eta = 60\%$ @ ACT
$\eta = 35\%$ @ Term.

} This assumes that future NSPS would apply to this in the same manner as existing NSPS

$\frac{46.2}{46.2+29.6} = 61$ % cap @ ACT.

$\frac{29.6}{46.2+29.6} = 39$ % cap @ Term

$E_{N_{ker,\,Ex.}} = (.61)(.6)(.395) + (.39)(.65)(.395)$

$= .1447 + .1003 = 0.245$

$\boxed{E_{N_{kerosene,\ existing}} = 0.245\ \#/gal}$ $\boxed{E_{N_{kerosene,\ NS}} = 0}$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By ______________________ Date ______________

Source ____

DISTILLATE FUEL OIL

η = 60% @ [illegible]
η = 35% @ [illegible].

THIS ASSUMES THAT FUTURE NSPS WOULD APPLY TO THIS IN THE SAME MANNER AS EXISTING NSPS.

$\frac{346.2}{346.2 + 169.5}$ = 67 % cap @ [illegible].

$\frac{169.5}{346.2 + 169.5}$ = 33 % cap @ [illegible].

E_N = (.67)(.4)(.593) + (.33)(.65)(.593) =
= .1589 + .1272 = 0.286

$E_{N\,\text{[illegible]}}$ = 0.286 #/gal

$E_{N\,\text{[illegible] oil}}$ ≈ 0

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 7/12/74

Source Petroleum St. & Tr. - Tanks

Summary

	Fix. Breathing	Fix. Working	lb/hr. Flt. Breathing	Flt. Working
✓ Motor Gasoline	2.85	0.116	0.285	0.0116
✓ Crude Oil	2.88	0.084	1.56	0.048
✓ Aviation Gas	2.85	0.116	1.35	0.055
✓ Service Naphtha	2.45	0.116	1.30	0.056
✓ Jet Fuel	1.40	0.116	0.68	0.054
Kerosene	0.593	—	0.195	—
Distillate Oil	0.593	—	0.286	—

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/11/84

Source Robertson S&T – Tanks

Determination of E_S

Ref 14 Tab III p 69-72

Of the 51 states (including DC), 21 have no regs for HC storage & loading. 30 have storage regs & 25 have transfer regs. Of these, 3 specifically do not include crude oil & 4 additional have regs only for new sources.

So:

① For crude storage, 23 (of 51) states have applicable regs
② For crude transfer, 18 (of 51) states have applicable regs
③ For all other fluids of concern, 27 have storage regs & 22 have transfer regs.

If we assume,

① Equal geographical distribution of sources
② $E_S = E_N$ for those states with appropriate regs since "state and local regulations ..... are similar to the proposed standards." Ref (14) p 32 [NSPS] std.

Then,

$$E_{S_{exist}} = f\left(E_U \text{ for states w/o regs} + E_N \text{ for states with regs}\right)$$

$$E_{S_{new}} = E_N$$ (due to NSPS already promulgated) except for [illegible] & [illegible], where [illegible], we assume to [illegible] them exempt

Ⓐ Crude oil

$$E_{S_{\substack{\text{crude oil}\\\text{exist}\\\text{storage}}}} = \left(\frac{28}{51}\right)(2.88) + \left(\frac{23}{51}\right)(1.56) = 1.581 + .704 = 2.29 \text{ [illegible]}$$

p 18 p 18
of these calcs

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/11/78

Source Petroleum [illegible] - Tanks

$$\boxed{E_{S_{\substack{\text{crude}\\ \text{dist}\\ \text{breath.}}}} = 3.29\ \frac{\text{lb}}{\text{bbl}}}$$

$$E_{S_{\substack{\text{crude}\\ \text{dist}\\ \text{wkg}}}} = \left(\frac{18}{51}\right)\left(.041\right) + \left(\frac{33}{51}\right)\left(.084\right) = .0149 + .0544 = .0713$$

$$\boxed{E_{S_{\substack{\text{crude}\\ \text{dist}\\ \text{wkg}}}} = 0.071\ \frac{\text{lb}}{\text{bbl}}}$$

(B) for gasoline:

$$E_{S_{\substack{\text{gas}\\ \text{dist}\\ \text{breath}}}} = \left(\frac{27}{51}\right)\left(.285\right) + \left(\frac{24}{51}\right)\left(2.85\right) = .1509 + 1.341 = 1.492$$

$$\boxed{E_{S_{\substack{\text{gas}\\ \text{dist}\\ \text{breath.}}}} = 1.49\ \frac{\text{lb}}{\text{bbl}}}$$

$$E_{S_{\substack{\text{gas}\\ \text{dist}\\ \text{wkg}}}} = \left(\frac{24}{51}\right)\left(.0116\right) + \left(\frac{27}{51}\right)\left(.116\right) = .005 + .066 = .071$$

$$\boxed{E_{S_{\substack{\text{gas}\\ \text{dist}\\ \text{wkg}}}} = 0.071\ \frac{\text{lb}}{\text{bbl}}}$$

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Calculations Done By [illegible] Date [illegible]

Source [illegible]

Ⓒ Aviation gas

$$E_{S_{\text{avgas}}} = \left(\frac{27}{51}\right)(1.35) + \frac{24}{51}(2.85) = .7147 + 1.3412$$

$$\boxed{E_{S_{\text{avgas}}} = 2.06\ \#/\text{BBL}}$$

$$E_{S_{\text{W\&B}}} = \left(\frac{27}{51}\right)(.055) + \left(\frac{24}{51}\right)(.116) = .0237 + .066$$

$$\boxed{E_{S_{\text{avgas}}} = 0.090\ \#/\text{BBL}}$$

Ⓓ Special Naphtha

$$E_{S} = \left(\frac{27}{51}\right)(1.30) + \left(\frac{24}{51}\right)(2.85) = .688 + 1.341$$

$$\boxed{E_{S_{\text{spnap}}} = 1.34\ \#/\text{BBL}}$$

$$E_{S_{\text{W\&B}}} = \left(\frac{27}{51}\right)(.056) + \left(\frac{24}{51}\right)(.116) = .0012 + .066$$

$$\boxed{E_{S_{\text{spnap}}} = 0.090\ \#/\text{BBL}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/11/74

Source [illegible] S,&T – Tanks

⑧ JET FUEL

$E_{S_{Breath}} = \left(\frac{27}{51}\right)(.65) + \left(\frac{24}{51}\right)(1.40) = .3441 + .6588$

$$\boxed{E_{S_{\substack{\text{JET FUEL}\\27/51\\\text{BREATH}}}} = 1.00 \ \#/\text{GAL}}$$

$E_{S_{W}} = \left(\frac{27}{51}\right)(.054) + \left(\frac{24}{51}\right)(.14)$

$$\boxed{E_{S_{\substack{\text{JET FUEL}\\27/51\\\text{WORK}}}} = 0.09 \ \#/\text{GAL}}$$

⑦ KEROSENE

$E_{S_{B}} = \left(\frac{27}{51}\right)(.295) + \left(\frac{24}{51}\right)(.593) = .1562 + .2791$

$$\boxed{E_{S_{\substack{\text{KER}\\27/51\\\text{BREATH}}}} = 0.435 \ \#/\text{GAL}}$$

⑥ DISTILLATE OIL

$E_{S_{Breath}} = \left(\frac{27}{51}\right)(.286) + \left(\frac{24}{51}\right)(.593) = .1514 + .2791$

$$\boxed{E_{S_{\substack{\text{DIS}\\27/51\\\text{BREATH}}}} = 0.431 \ \#/\text{GAL}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/11/78

Source Petroleum S&T - Tanks

Summary Of E_s: #/gal

	EXISTING		NEW	
	BREATHING	WORKING	BREATHING	WORKING
MOTOR GASOLINE	1.49	.071	.285	.0116
CRUDE OIL	2.29	.071	1.56	.048
AV GAS	2.06	.09	1.35	.055
JP NAPHTHA	1.34	.09	1.30	.056
JET KER.	1.00	.09	.65	.054
✓ KEROSENE	.435	—	.435	---
✓ DISTILLATE OIL	.431	—	.411	—

← Assumed to be included in present NSPS

[illegible]

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Computation Sheet For Industrial Factors

Calculations Done By Hume Date 1/20/75

Source Industrial Surface Coating

Ref (26) states 1972 Production of Paints, Varnishes, Lacquers for industrial use = 2362 liters ×10^6

$(2362 \times 10^6)(0.2642) = 624 \times 10^6$ gals in 1972

Ref (19) p VI-29 states

1966 Production = 394×10^6 gals

1970 Production = 445×10^6 gals

Using the data from 1966 → 1972

$$P_c = \sqrt[6]{\frac{624}{394}} - 1.0 = 0.0778$$

$$\boxed{P_c = 0.078}$$ compound

Our analysis will cover all industrial surface coating except

① Automotive industry (covered under "Automobile Ass'y Plants")
② Those other surface coating.

From Ref (26) the major categories are

(a) Steel, strip & coil coating (~40%)
(b) Paper & paperboard coating (~40%)
(c) Metal treatment (~16%)
(d) Major appliances (~2%)
(e) Other (~2%)

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 1/[illegible]/75

Source Industrial Surface Coating

Of the 2362x10^6 liters produced in 1972, 213x10^6 liters went to the automotive industry, the remaining 2149x10^6 liters to be considered within this study.

$$1975 \text{ Production} = (2149\times10^6)(0.2642)(1.078)^3 = 711.3\times10^6 \text{ gallons}$$

No specific K could be found for this category. Since it affects such a wide spectrum of the mfg industry, we will assume a gen'l K for "Advanced processed goods" from Ref ([illegible]) p51.

Avg of the years 1965 - 1973 = 82%

$$\boxed{K = 0.82}$$

$$A = \frac{711.3\times10^6}{0.82} = 867.4\times10^6$$

$$\boxed{A = 867.4\times10^6 \text{ gals}}$$

Ref ([illegible]) states 8,000 new spray booths each year out of 50,000 – 100,000 establishments

P_B will be based on twice the allowable IRS depreciation guideline for the "Mfg of machines.... Mfg of Electrical Equip't" of 12 yrs

$$P_B = \frac{1}{2(12)} = 0.042$$

$\boxed{P_B = 0.042}$ simple

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/26/76

Source Industrial Surface Coating

Ref (75) p 4.2-1 gives uncontrolled emission factors for

Paint — 1120
Varnish-Shellac — 1000
Lacquer — 1540
Enamel — 840
Primer — 1320
} #/ton

Previous work (See "Industrial Tables – Paint & Industrial Tables Varnish) determined the following

631×10⁶ gallons paint (1975)
1.099×10⁶ tons varnish (1975)
} total liquid (trade & industrial)

From Ref (61), the total surface coating production (1972) was 4124 ×10⁶ lbs of which 2362 ×10⁶ lbs was industrial

$\frac{2362}{4124} = 57\%$

631×10⁶ (.57) = 360×10⁶ gals paint

$\frac{1.099\times10^6 (.57)(2000)}{7.0} = 179\times10^6$ gals varnish

Ref (75) p 4.2-1

Ref (60) p 4 indicates
% Lacquer = $\frac{82.2}{197.5}$ = 41.6% of paint

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Computation Sheet For Industrial Factors

Calculations Done By Hyman Date 1/20/75

Source Industrial Surface Coating

$(360 \times 10^6)(.403) = 145 \times 10^6$ gallons lacquer

$\Sigma = 684$ vs 711

Assume that enamel + primer are part of paint

$$\% \text{ Paint, enamel, primer} = \frac{360}{684} = 52.6\%$$

$$\% \text{ varnish} = \frac{179}{684} = 26.2\%$$

$$\% \text{ lacquer} = \frac{145}{684} = 21.2\%$$

From Ref ㉓ p 4.2-1 the weight of paint is 10-15 lb/gal (Assume Avg = 12.5)

The weight of varnish = 7 lb/gal

Choosing emission factors

Paint — 7 lb/gal
Varnish — 3.5 lb/gal
Lacquer — 9.63 lb/gal
Enamel — 5.25 lb/gal
Primer — 8.25 lb/gal

$$\frac{7.0 + 5.25 + 8.25}{3} = \text{Avg of paint, enamel \& primer} = 6.83$$

$$E_{HC} = (.526)(6.83) + (.262)(3.5) + (.212)(9.63) = 3.593 + .917 + 2.042$$

$$\boxed{E_{HC} = 6.55 \text{ lb/gallon}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hoffman Date 1/20/75

Source Industrial Surface Coating

E_{NHC}

There is no "typical" size coating operation to which a specific control method can be applied. There are many control techniques which could be used depending on the nature of the emission, the hourly rate & the size of the process. Some of these control methods are:

① Afterburners (99% η)
② Activated carbon (90% η) ← Ref (15) p42-1
③ Reformulation to non-reactive solvents
④ Electrocoating (97-98%) ← Ref [illegible] p1

Based on the "typical controls" that could be applied to the industry, we will estimate that a control of @ least 90% could be attained.

$$E_N = (1-0.90)(6.55) = 0.655$$

$$E_{N_{HC}} = 0.655 \text{ lb/gallon}$$

E_S

From Ref [illegible] 13 states have solvent regs, which are, presently operating, similar to LAAPCD Rule 66 (Ref [illegible])

$$E_S = f\left[\left(\frac{13}{50}\right)(E_{66}) + \left(\frac{37}{50}\right)(E_U)\right]$$

Rule 66 indicates 3 lb/hr or 15 lb/day or 85% control

15 lb/day represents the tightest level if one assumes a 16 hr/day schedule. If we also assume 5 days/wk operation & 6.8 rev/month (Ref [illegible] p 18)

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/20/78

Source Industrial Surface Coating

$$\left(15\ \frac{LB}{day}\right)\left(\frac{6\ days}{WK}\right)\left(52\ \frac{WK}{YR}\right) = \frac{LB}{YR \cdot BOOTH} = 4680$$

Ref (54) p 18 indicates an average uncontrolled emission of $6.8\ \frac{TONS}{YR \cdot booth}$. If this represents 50% of the total paint used (Ref (19) p 4.2-1), then the annual paint usage per booth is

$$\left(\frac{6.8}{.5}\right) = 13.6\ \frac{TONS}{YR \cdot booth}$$

$$E_{SS} = \frac{4680}{13.6} = 344\ LB/TON$$

"Avg" weight of "avg" primer = (.526 + .212)(12.6) + (.262)(7.0) = 9.285 + 1.834 = 11.1 LB/GAL

$$E_{S} = \frac{344\ \frac{LB\ SS}{TON\ LIQ}}{\frac{2000\ LB\ LIQ}{TON\ LIQ}} \times 11.1\ \frac{LB\ LIQ}{GAL} = 1.909\ LB/GAL$$

$$E_{S_{HC}} = 1.909$$

$$E_{S_{HC}} = \left(\frac{13}{50}\right)(1.909) + \left(\frac{37}{50}\right)(6.55) = 0.496 + 4.847 = 5.34$$

$$\boxed{E_{S_{HC}} = 5.34\ LB/GAL}$$

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 1/17/75

Source Textile Processing

Textile Processing consists of many varied & separate processes & uses 100's of various chemical compositions. To define this category we will evaluate the operations

① Heat Setting/Finishing

② Texturizing

③ Dyeing

④ Carpet Mfg.

Ref ⁽²³⁹⁾ serves as the major reference.

Heat Setting/Finishing

in 1974 230×10^6 kg/yr of polyester texturized & knit fabric are finished
343×10^6 kg/yr of polyester/cotton finished fabric.

Ref (239) p 49

$$\frac{(343+230)(10^6)\ \text{kg} \times 2.2\ \frac{\text{lb}}{\text{kg}}}{2000} = 0.630 \times 10^6 \text{ tons/yr}$$

From Ref (239) p 91 tab 11 we can determine P_c. Although a simple or compounded growth is not specified, values in this report have all been on a cmpd basis. We will assume this table to be no different.

$$(1+R)^8 - 1 = .86$$

$$\boxed{P_{c_{HSF}} = 0.081} \text{ cmpd}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hunter Date 1/17/75

Source Textile Processing

$$1975\ \text{Prod} = (0.630\times10^6)(1+.081) = 0.681\times10^6\ \text{tons}$$

specific value of K could be found. Ref (144) p 48 Tab 1 gives the avg K for textile mfg (1968-1973) as 86%. We will use that value

$$\boxed{K = 0.86}$$

← we will assume this K for all operations treated in this study.

$$A = \frac{0.681\times10^6}{0.86} = 0.792\times10^6$$

$$\boxed{A_{NSIP} = 0.792\times10^6\ \text{tons}}$$

Ref [illegible] p 32 gives the IRS allowable depreciation of 12 yrs for the "Finishing and Dyeing" of "Textile mill products"
Assuming twice the allowable

$$P_B = \frac{1}{(2)(12)} = 0.0417$$

$$\boxed{P_B = 0.0417}$$ simple

← We will assume this P_B for all operations treated in this study.

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 1/13/74

Source Textile Processing

Texturizing

Ref ⑳⑨ p68

Estimated 1974 "Production Capability" (capacity) = .77×10⁹ kg

Ref ⑳⑨ p91

$$(1+P_c)^{8.5}-1 = .20$$

$$\boxed{P_c = 0.023}$$ CMPD

$$A = \frac{(.77\times10^9)(2.2)}{2000}(1+.023) = 0.866\times10^6$$

$$\boxed{A_r = 0.866\times10^6 \text{ TONS}}$$

Dyeing

Ref ⑳⑨ p64

1974 Production = 230×10³ kg/hr

p95 indicates that $P_c = 0$ for dyeing

$$\boxed{P_c = 0.0}$$

for A K = 0.26

$$A = \frac{(230\times10^3)(2.2)}{(2000)(.26)} = .974 \frac{\text{TONS}}{\text{YR}}$$

This value is so low, we will not include it in the study. In addition, emissions (HC) avg 0.04 lb/ton fabric - which is also insignificant

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Computation Sheet For Industrial Factors

Calculations Done By ________ Date 1/17/75

Source Textile Processing

Carpet Mfg.

Ref ([illegible]) p 70

1974 Production = 1360×10⁶ [illegible]

Ref ([illegible]) p 91

$$(1+P_c)^8 - 1 = 0.51$$

$$\boxed{P_c = 0.053} \text{ compounded}$$

$$A = \frac{(1360 \times 10^6)(2.2)}{(2000)(.86)}(1+.053) = 1.832 \times 10^6$$

$$\boxed{A_{cm} = 1.832 \times 10^6 \text{ tons}}$$

Summary

	K	A×10⁶	P_c^*	P_s^{**}
Non Sewing/Finishing	0.86	0.792	0.081	0.0417
Texturizing	↓	0.866	0.0	↓
Carpet Mfg	↓	1.832	0.053	↓

* comp'd
** simple

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Computation Sheet For Emission Factors

Calculation Done By Hunter Date 1/17/78

Source "Textile" Mfg

Hydrocarbon emission factors for this source category must be used with reluctance (Ref [illegible]) We continue.

Heat Setting/Finishing

For polyester broadwoven & knit fabric, $E_U = 17.0$ kg/1000 kg $\left(20 \frac{\text{lb}}{\text{ton}}\right)$
For polyester/cotton, $E_U = 1.80 \frac{\text{kg}}{1000\,\text{kg}}$ (3.60 lb/ton)

1974 Prod. Poly. bw & knit = 230×10^6 kg
1974 Prod Poly/Cotton = 343×10^6 kg
573

$$E_{U_{H\&F}} = \left(\frac{230}{573}\right)(20) + \left(\frac{343}{573}\right)(3.60) = 8.03 + 2.15 = 10.18$$

$$\boxed{E_{U_{HC,\,H\&F}} = 10.18 \ \text{lb}/\text{ton matl}}$$

Ref ([illegible]) p 72, "Demisters on finishing operations appear to provide 'the best' overall control of condensible hydrocarbons . . . ."

Ref ([illegible]) p 81

$\eta = 77\%$ for Poly/cotton
$= 98\%$ for Poly

$$E_H = f\left[\left(\frac{230}{573}\right)(.98) + \left(\frac{343}{573}\right)(.77)\right] = .393 + .461 = .854$$

$$E_H = (1 - .854)(10.18) = 1.486$$

$$\boxed{E_{H_{H\&F}} = 1.486 \ \text{lb}/\text{ton matl}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/17/78

Source Textile Processing

Although this industry has solvent HC emissions, most State's regulate by means of "nuisance" laws - opacity & odor. Ref ([illegible]) p 67 indicates that this is effective to approx 70%

$\therefore E_S = (1-.70)(10.18) = 3.054$

$$\boxed{E_{S_{HC} \atop NSIP} = 3.054\ \mathrm{lb/ton\ matl}}$$

Texturizing

Ref ([illegible]) p 63

$E_{U_{HC} \atop TEXT} = 2.3\ \frac{kg}{1000\ kg}\ (4.6\ \mathrm{lb/ton})$

$$\boxed{E_{U_{HC} \atop TEXT} = 4.60\ \mathrm{lb/ton\ matl}}$$

Ref ([illegible]) p 72

" .... texturizing plants utilizing electrostatic precipitators .... are considered best controlled plants."

Ref ([illegible]) p 79 $R = 95\%$

$E_U = (1-.95)(4.60) = 0.23$

$$\boxed{E_{U_{HC} \atop TEXT} = 0.23\ \mathrm{lb/ton\ matl}}$$

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Computation Sheet For Emission Factors

Calculations Done By Hupper Date 1/13/75

Source Textile Processing

$E_N = f(\text{capacity, codes})$ Ref (29) p 63 $E_S = f(80\%)$

$$E_S = (1-.8)(4.60) = 0.92$$

$$\boxed{E_{S\,NC\,\text{TEXT.}} = 0.92\ \text{lb/ton mat'l}}$$

Carpet Mfg

Ref (29) p 70, 71

$$E_{U\,\text{CARP.}} = (0.1 + 0.7)\ \frac{\text{lb}}{1000\,\text{kg}} = 0.8\ \text{lb/ton mat'l}$$

$$\boxed{E_{U\,NC\,\text{C.MFG.}} = 0.80\ \text{lb/ton mat'l}}$$

No specific control methods are mentioned for carpet mfg. However, we will assume that NSP's could do the job at 95% η as in the entire textile industry.

$$E_N = (1-.95)(0.80) = 0.04$$

$$\boxed{E_{N\,NC\,\text{C.MFG.}} = 0.04\ \text{lb/ton mat'l}}$$

$E_S = f(\text{capacity, codes}) = f(10\%)$ Ref (29) p 70

$$E_S = (1-.10)(0.80) = 0.72$$

$$\boxed{E_{S\,NC\,\text{C.MFG.}} = 0.72\ \text{lb/ton mat'l}}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/13/75

Source Textile Processing

Summary

	Eu	En	Es
Sewing/Finishing	10.18	1.486	3.054
Tentering	4.40	0.23	0.92
Carpet Mfg	0.80	0.04	0.72

APPENDIX 4-C

DETERMINATION OF INPUT VARIABLES
FOR
THE PETROLEUM INDUSTRY

1 of 2

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 12/20/74

Source FCCU – Petroleum Refineries

Ref (49) p 482 states that the capacity of FCC units in 1968 was

$$\left(3.609\times10^6 \frac{\text{bbl}}{\text{day}}\right)\left(330 \frac{\text{days}}{\text{yr}}\right) = 1.19\times10^9 \frac{\text{bbls}}{\text{feed}}$$

From Ref (44) p 82. Growth is estimated to be about 685,000 $\frac{\text{bbl feed}}{\text{day}}$ over the next five year period (1973 basis)

On a yearly basis (Assuming equal yearly growth), updating the 1968 data

$$1.19\times10^9 + 7\left(\frac{685{,}000}{5}\right)(330) = 1.506\times10^9 \frac{\text{bbls feed}}{\text{yr}} = A$$

$$\boxed{A = 1.506\times10^9 \frac{\text{bbls feed}}{\text{yr}}}$$

Growth rate in the production of other primary liquid hydrocarbons can be obtained from Ref (??) p 229, [illegible]. This has been growing at a steadily compounded rate.

Using 1971 & 1960 data

$$R_c = \sqrt[11]{\frac{5500}{3530}} - 1.0 = 4.22\%$$

$$\boxed{R_c = 0.0422}$$ compound

From Ref (94) p III-89

$$K = \frac{\text{Production}}{\text{Capacity}} = \frac{11\times10^6}{13\times10^6} = 0.85 \qquad \boxed{K = 0.85}$$

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Computation Sheet For Industrial Factors

Calculations Done By Magee Date

Source

Ref (37) p 31 IRS allowable depreciation = 16 yrs for

"Petroleum refining: Includes assets used for the distillation, fractionation and catalytic cracking of crude petroleum ....."

Assuming twice the IRS guideline

$$P_d = \frac{1}{2(16)} = 0.031$$

$$\boxed{P_d = 0.031}$$

Magee

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 12/30/7[illegible]

Source FCCU

Particulate

Ref (75) p 9.1-3 TAB 9.1-1

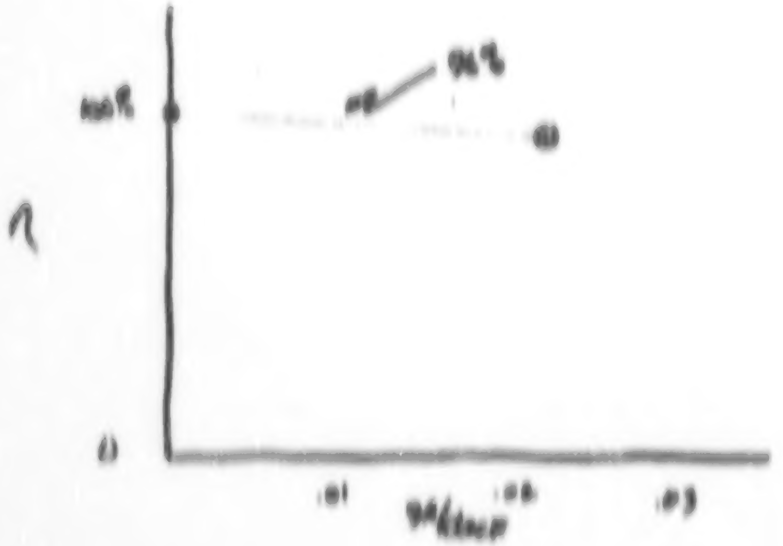
$$E_{u\,part} = 242\ \text{lb}/1000\ \text{bbl fresh feed} = 0.242\ \text{lb}/\text{bbl}$$

$$\boxed{E_{u\,part} = 0.242\ \text{lb}/\text{bbl fresh feed}}$$

Ref (41) p17 states NSPS reg'n = 0.022 gr/dscf

This corresponds to an efficiency (ESP) of about 95%.

Page 19 (same Ref) states that two control equipment designers guarantee a level of 0.01 gr/dscf



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Computation Sheet For Emission Factors

Calculations Done By Vogel Date 12/30/74

Source FCCU

$$E_N = (1-.96)(.242) = 0.0097$$ ELECTROSTATIC PRECIPITATOR

$$\boxed{E_{N_P} = 0.0097 \ \text{LB}/\tfrac{\text{BBL}}{\text{FEED}}}$$

As stated $E_{S_{NEW}} = f(93\% \ \eta)$

$$E_{SP_{NEW}} = (1-.93)(.242) = 0.0169$$

$$\boxed{E_{SP_{NEW}} = 0.0169 \ \text{LB}/\tfrac{\text{BBL}}{\text{FEED}}}$$

Emission.

The process weight rate is defined as the catalyst recirculation rate. Ref (44) p 19 indicates a typical rate of

$$50 \ \text{tons}/\text{min} \times 60 \ \text{min}/\text{hr} = 3000 \ \text{tons}/\text{hr}$$

$$3000 \ \frac{\text{tons}}{\text{hr}} \times 2000 \ \frac{\text{lb}}{\text{ton}} = 6 \times 10^6 \ \text{lb}/\text{hr}$$

Ref (41) p 42 ff gives 1971 breakdown of geographical capacity distribution. Of the 39 states with oil refineries, 78% of the total capacity is located in 8 states.

Texas – 27.3%
Cal. – 15.5%
Louis. – 10.9%
Ill. – 6.6%
Penn. – 5.1%
Ind. – 4.7%
Ohio – 4.3%
N.J. – 4.1%
78.5%

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/30/74

Source FCCU

We will base Es on the 76% per State basis & 24% using the generalized PWR curve.

From Ref (84) & (175), the allowable emissions are

TEXAS = 300 lb/hr

CAL. – 40 (Ref (156) LAAPCD)

Louisiana – 96

ILL. – 100 (special eq)

Penn = .02 gr/dscf as E_H = .0097 lb/bbl

So, for the 50,000 bbl/day unit

$$\frac{(.0097)(50{,}000)}{24} = 20 \text{ lb/hr} \leftarrow \text{Penn}$$

Ind.

$E_s = (1-.9997)(.242) = .000073$ lb/bbl

$(.000073)(50000)/24 = 0.152$ lb/hr ← Indiana

This value seems unreasonably stringent. Therefore assume equal to New Jersey which is the most stringent of all the other states

Indiana = 30 lb/hr

Ohio = 96 lb/hr

NJ. = 30 lb/hr

All others = 107 lb/hr

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hopper Date 12/20/74

Source FCCU

$$E_{S_{PART}} = \Big[(300)(.273) + (40)(.135) + (94)(.104) + (100)(.066) + (20)(.051) + (30)(.047) + (94)(.043) + (30)(.041) + (107)(.242)\Big]$$

$$= 81.9 + 5.4 + 9.8 + 6.6 + 1.0 + 1.4 + 4.1 + 1.2 + 25.9$$

$$= 137.3 \ \text{LB/HR}$$

For the 50,000 BBL/DAY UNIT

$$\frac{(137.3)(24)}{(50,000)} = 0.066 \ \text{LB/BBL FEED}$$

$$\boxed{E_{S_{PART}} = 0.066 \ \text{LB/BBL FEED}}$$

CO

Ref (15) p 9.1-3 TAB 9.1-1

$$E_{U_{CO}} = 13,700 \ \text{LB/1000 BBL} = 13.7 \ \text{LB/BBL FEED}$$

$$\boxed{E_{U_{CO}} = 13.7 \ \text{LB/BBL FEED}}$$

Ref (14) p 17 Using a waste heat boiler, NSPS requires 99.5% efficiency

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 10/30/79

Source FCCU

$E_{N_{CO}} = (1-.995)(13.7) = 0.0685 \text{ lb/bbl}$

$$\boxed{E_{N_{CO}} = 0.0685 \text{ lb/bbl fresh}}$$

$$E_{S_{CO}\,new} = f(NSPS) = E_{N_{CO}} = 0.0685$$

$$\boxed{E_{S_{CO}\,new} = 0.0685 \text{ lb/bbl fresh}}$$

Since there are no regs for CO from existing plants, $E_S = E_U$

$$\boxed{E_{S_{CO}\,exist} = 13.7 \text{ lb/bbl fresh}}$$

SO_x

SO_x emissions occur during regeneration of the catalyst. From Ref ⑨⑧ p 9.1-3 TAB 9.1-1 indicates an uncontrolled emission factor

$E_{U_{SO_x}} = 493 \text{ lb/1000 bbl} = 0.493 \text{ lb/bbl}$

$$\boxed{E_{U_{SO_x}} = 0.493 \text{ lb/bbl fresh}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 12/31/74

Source FCCU

(Ref (31) p 72)

Since there is no demonstrable control, & emissions appear to be low, we will set $E_U = 0.0$ as we have done in the past

$$\boxed{E_{H_2SO_4} = 0.0}$$

Since the SO_x emissions are the result of catalyst regeneration wherein surface sulfides are oxidized, we will assume that "fuel burning" reg's apply

From Ref (31) p 9.1-9, the weight of crude is 336 lb/BBL

$$wt \% S = \frac{0.493}{336} = 0.15\%$$

Since this is below State reg's regarding % S, $E_S = E_U$

$$\boxed{E_{S_{SO_x}} = 0.493 \text{ lb}/\frac{\text{BBL}}{\text{Feed}}}$$

Sulfides

There are substantial emissions of $\boxed{H_2S}$ from FCC units. Since there are NSPS for process gas combustion, we will treat H_2S emissions within that context.

Trace Metals

No specific info could be located regarding trace metal emissions. However, Ref (43) p 45 states:

" ..... chemical composition of the solids discharged from the FCC regenerators differ little from the composition of equilibrium catalyst... "

Ref (43) p 26 TAB 41 gives % composition of equilibrium catalyst.

12.9% is alumina. We will apply this % to the particulate emission factors, until better information becomes available.

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 12/31/74

Source FCCU

$$E_{U_{TM}} = (.129)(.242) = .0312$$

$$\boxed{E_{U_{TM}} = .0312 \ \text{LB}/\text{BBL Feed}}$$

$$E_{N_{TM}} = (.129)(.0097) = .0013$$

$$\boxed{E_{N_{TM}} = 0.0013 \ \text{LB}/\text{BBL Feed}}$$

Regs for particulates would result in "de facto" control of trace metals

$$E_{R_{TM}} = (.129)(.0169) = .0022$$

$$\boxed{E_{R_{TM}} = 0.0022 \ \text{LB}/\text{BBL Feed}}$$

Since an ESP could, generally, be retrofit to existing installations, $E_{11(d)} = E_N$

$$\boxed{E_{11(d)_{TM}} = 0.0013 \ \text{LB}/\text{BBL Feed}}$$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hoffman Date 1/2/76

Source Petr. Ref. - FCCU

NH3

Ref (11) p 21-3 TABLE 21-1

$$E_{U_{NH_3}} = 54 \text{ lb}/1000\text{ gal feed} = .054 \text{ lb/gal}$$

$$\boxed{E_{U_{NH_3}} = 0.054 \text{ lb/gal feed}}$$

It is conceivable, although impractical, (due to the low emission rate) to install a water scrubber in series with the amine scrubber (for H_2S — see Process Gas Combustion) to remove the NH_3.

Since this would be a transfer of technology, we will assume an $\eta = 98\%$. This is conceivable considering the high solubility of NH_3 in water.

$$E_{N_{NH_3}} = (1-.98)(.054) = .0011$$

$$\boxed{E_{N_{NH_3}} = 0.0011 \text{ lb/gal feed}}$$

Since a scrubber could be, generally, retrofit to an existing installation, we will assume $E_{IIId} = E_N$

$$\boxed{E_{IIId} = 0.0011 \text{ lb/gal feed}}$$

Since there are no regs for NH_3 emissions, $E_S = E_U$

$$\boxed{E_{S_{NH_3}} = 0.054 \text{ lb/gal feed}}$$

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 5/23/75

Source Gasoline Additive Mfg.

Ref (276) p[illegible] gives K of 0.62 in 1973

Assume this value to remain constant

$\boxed{K' = 0.62}$

Ref (276) p[illegible] shows estimated 1975 production @
1975 Prod = 382×10^6 lbs

$$\frac{382\times10^6}{(2000)(.62)} = 0.308\times10^6 \text{ tons} = \text{total 1975 capacity}$$

Ref (277) App. B Vol. II states

92% by Na-Pb Alloy Process
8% by Electrolytic Process

$$A_{NaPb} = (.308\times10^6)(.92) = .283\times10^6$$

$$\boxed{A_{NaPb} = 0.283\times10^6 \tfrac{\text{tons}}{\text{year}}}$$

$$A_{Elec.} = (0.08)(.308\times10^6) = 0.025\times10^6$$

$$\boxed{A_{Elec.} = 0.025\times10^6 \tfrac{\text{tons}}{\text{year}}}$$

Ref (278) p[illegible] "Thus production units would be [illegible] or expanded during the 1970's . . ."

Assume $\boxed{P_g = 0.0}$

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Computation Sheet For Emission Factors

Calculations Done By Hunter Date 5/23/75

Source Gasoline Additive Mfg

$\boxed{A}$ SODIUM LEAD ALLOY PROCESS

Ref (276) p 91 gives 80% TEL, 20% TML

$E_{U_{TEL}} = 4 \text{ lb/ton prod}$ $E_{U_{TML}} = 150 \text{ lb/ton prod.}$

$E'_{U_{Pb}} = (4)(.8) + 150(.2) = 3.2 + 30 = 33.2$

Also

$E_{U_{\substack{recovery\\furnace}}} = 55 \text{ lb/ton product}$ Ref (276) p 92

$E_{U_{Pb}} = 55 + 33.2 = 88.2$

$$\boxed{E_{U_{Pb}} = 88.2 \text{ lb/ton product}}$$

$\underline{E_N}$

Since the recovery furnaces are similar to 2° lead furnaces we will assume an $\eta = 97\%$ using a baghouse or high energy scrubber (see "Emission Factors - 2° lead)

$(55)(1-.97) = 1.65$

From Ref (276) p 93

$\eta_{TEL} = 70\%$ (Packed bed scrubber)

$\eta_{TML} = 95.5\%$ (" " ")

$E_N = (4)(.8)(1-.7) + 150(1-.955)(.2) + 1.65$

$= 0.96 + 1.35 + 1.65 = 3.96$

$$\boxed{E_N = 3.96 \text{ lb/ton product}}$$

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Computation Sheet For Emission Factors

Calculations Done By Hoffer Date 5/28/75

Source Gasoline Additive Mfg

Since we are only concerned with E_{NEW} of baghouses/scrubber could in most cases be retrofit to existing installations.

$$E_{NEW} = 3.96 \ \frac{lb}{ton\ product}$$

Ref. (277) Vol II "Section II-B

$$E_S = 10.78 \ \frac{lb}{ton\ product}$$

B Electrolytic Process

The electrolytic process does not use a lead recovery furnace. Emission factors will be assumed identical to NaPb alloy process w/o the furnace.

$$E_{U_{Pb}} = 88.2 - 55 = 33.2$$

$$E_{U_{Pb}} = 33.2 \ \frac{lb/ton}{product}$$

$$E_{ind} = 3.96 - 1.65 = 2.31$$

$$E_{ind} = 2.31 \ lb/ton$$

$$E_S = 4.1 \ lb/ton$$ Ref (277) Vol. II Sec II-B

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Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 12/31/74

Source Petroleum Refineries - TCCU & HCCU

Ref (43) p85 states

". . . . the FCC type dominates and no TCC or HCC units have been sold for about 10 years in this country."

∴ The growth rate of this equipment is, therefore, assumed to be negative or zero (assume zero)

$$\boxed{P_c = 0}$$

Ref (45) p84 Tab 28 gives % breakdown of catalytic crackers

$$\left.\begin{aligned} FCC &= 85.4\% \\ TCC &= 11.4\% \\ HCC &= 3.2\% \end{aligned}\right\} \text{1972 basis}$$

$$A_{TCC} = \frac{\text{1972 } \overset{\text{FCC}}{\text{capacity}}}{.854} \times .114$$

$$A_{HCC} = \frac{\text{1972 FCC capacity}}{.854} \times .032$$

$$\text{1972 FCC capacity} = 1.29 \times 10^9 \text{ bbls} + 4\left(\frac{485000}{8}\right)(330) = 1.371 \times 10^9 \text{ bbls}$$

$$A_{TCC} = \frac{1.371 \times 10^9}{.854} \times .114 = 1.83 \times 10^8 \text{ bbls}$$

$$\boxed{A_{TCC} = 1.83 \times 10^8 \text{ bbls}}$$

$$A_{HCC} = \frac{1.371 \times 10^9}{.854} \times .032 = 5.14 \times 10^7 \text{ bbls}$$

$$\boxed{A_{HCC} = 5.14 \times 10^7 \text{ bbls}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hamer Date 12/31/79

Source Pers. Communications - TCCU & HCCU

Assume same K as for FCC units

$$\boxed{K = 0.85}$$

Since $P_c = 0$, obsolete units would be replaced by FCC units.

$$\boxed{\therefore P_B = 0}$$

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Computation Sheet For Emission Factors

Calculations Done By Horner Date 12/31/74

Source Petr. Refineries - TCCU & HCCU

From Ref (75) p 9.1-3 TAB 9.1-1

$E_{U_P} = .017$ LB/BBL FEED

$E_{U_{NH_3}} = 0.006$ LB/BBL FEED

$E_{U_{SO_2}} = .060$ LB/BBL FEED

$E_{U_{CO}} = 3.8$ LB/BBL FEED

Controls for H/C & CO emissions could be assumed to be the same as for FCC units

$E_{N_P} = (1-.96)(.017) = .0007$

ELECTROSTATIC PRECIPITATOR

$E_{N_P} = 0.0007$ LB/BBL FEED

$E_{N_{CO}} = (1-.995)(3.8) = 0.019$

$E_{N_{CO}} = 0.019$ LB/BBL FEED

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 5/2/75

Source Pet. Ref's – [illegible]

Ref (15) p 9.1-3 Table 9.1-1

Ammonia

$$E_{U_{NH_3}} = 0.006\ \text{lb}/\text{bbl feed}$$

Ref (41) p 15 "Each of the above types of catalytic cracking units [FCC, TCC & HCC] employ the same general process principals and feed stocks to produce similar products."

We will assume control similar to that for NH_3 emissions from FCCU – water scrubber, even though emissions are extremely low. (See "Emission Factors – Petr. Ref. – FCCU").

$$E_{ctl} = (1-.98)(.006) = 0.00012$$

$$E_{ctl_{NH_3}} = 0.0001\ \text{lb}/\text{bbl feed}$$

Since there are no regs for NH_3, $E_S = E_U$

$$ES_{NH_3} = 0.006\ \text{lb}/\text{bbl feed}$$

Trace Metals

Assume that the trace metal emissions are a function of the particulate emissions & the % of metals within the catalyst. See "Emission Factors" – Petr. Ref. – FCCU"

12.9% of catalyst is alumina

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Computation Sheet For Emission Factors

Calculations Done By Hanna Date 5/5/78

Source Petroleum Ref's - TCCU / HCCU

$E_{U_{TM}} = (0.129)(E_{U_{REF}})$

Ref ㉝ p 9.1-3 TAB 9.1-1 $E_{U_{REF}} = 0.017 \ \frac{lb}{BBL \ FEED}$

$E_{U_{TM}} = (0.129)(0.017) = 0.0022$

$\boxed{E_{U_{TM}} = 0.0022 \ \text{LB}/\text{BBL FEED}}$

Using the control info from "Emission Factors - Petr. Ref - FCCU"

$R_{ESP} = 93\%$

$E_{WD_{TM}} = (0.0022)(1-.93) = 0.00015$

$\boxed{E_{WD_{TM}} = 0.00015 \ \text{LB}/\text{BBL FEED}}$

We will assume $E_{S_{TM}}$ to be the same as for FCCU (See calcsheets)

$\boxed{E_{S_{TM}} = 0.0022 \ \text{LB}/\text{BBL FEED}}$ (COINCIDENTLY SAME AS $E_{U_{TM}}$)

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date [illegible]

Source Petroleum Refinery - Process Gas Combustion

Ref (34) p 87:

"For a typical 200,000 bbl/day refinery producing 30×10^6 scf of process gas ...."

For a 1975 capacity of 1.506×10^9 bbl/year, we would have,

See "Industrial Factors - Petroleum Refinery - FCCU"

$$\frac{200,000}{30 \times 10^6} = \frac{1.506 \times 10^9}{X}$$

$$X = 2.259 \times 10^{11} \text{ FT}^3 \text{ process gas}$$

$$\boxed{A = 0.226 \times 10^{12} \text{ FT}^3 \ \frac{\text{process gas}}{\text{yr}}}$$

Assume K to be equal to that for FCCU

$$\boxed{K = 0.25}$$

Assume P_c & P_s to be equal to that for FCCU

$$\boxed{P_c = 0.0422} \text{ compound}$$

$$\boxed{P_s = 0.081} \text{ simple}$$

K, P_c & P_s were det'd for refineries, in gen'l, so they would be applicable to process gas combustion as well as FCCU.

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/8/75

Source Pet. Ref. Process Gas Combustion

From Ref (15) p 9.1-5 Tab 9.1-1

Particulates

$E_{Up} = 0.02$ lb/1000 ft³ gas

Controls for particulate emissions from the combustion of gases are not employed. Because of this & the seemingly low emission rate, we will set $E_{U} = 0.0$ to determine the hypothetical impact of 100% control for control priority purposes.

$E_{Hp} = 0.0$ ⟵ This is changed. See p7

Ref (54) p 93ff relates that in 1971

253 refineries had a capacity of 12.681 x 10⁶ bbl/s day

$$\text{Avg Plant capacity} = \frac{12.68 \times 10^6}{253} = 50{,}118 \frac{\text{bbl}}{\text{day} \cdot \text{plant}}$$

Typ amt of process gas burned = x

$$\frac{200{,}000}{30 \times 10^6} = \frac{50{,}000}{x} \qquad x = 7.5 \times 10^6 \frac{\text{dscf}}{\text{day}}$$

From Ref (64) p 14-8 HV of process gas is 1500 BTU/ft³

$$\frac{.02 \times 10^{-3} \frac{\text{lb}}{\text{ft}^3}}{1500 \frac{\text{BTU}}{\text{ft}^3}} = .0133 \text{ lb}/10^6 \text{BTU}$$

Since E_U is less than any State reg. (Ref (61) & (101)), $E_S = E_U$

$E_{Sp} = 0.02$ lb/1000 ft³ gas

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/8/78

Source Petr. Ref. - Process Gas Combustion

SO$_2$

Ref (44) p.5 states ". . . . process gas that may contain more than 5 percent hydrogen sulfide by volume."

$$\frac{\left(\frac{.05\ \text{FT}^3\ H_2S}{\text{FT}^3\ \text{gas}}\right)\left(34\ \frac{\text{lb}\ H_2S}{\text{mole}\ H_2S}\right)}{387\ \frac{\text{FT}^3\ H_2S}{\text{mole}\ H_2S}} = .00439\ \frac{\text{lb}\ H_2S}{\text{FT}^3\ \text{gas}}$$

$$2\ H_2S + 3O_2 \rightarrow 2H_2O + 2\ SO_2$$

$$\frac{\text{wt}\ SO_2}{\text{wt}\ H_2S} = \frac{64}{34} = 1.882$$

$$.00439 \times 1.882 \times 1000 = 8.26\ \text{LB}/1000\ \text{FT}^3$$

$$\boxed{E_{U_{SO_2}} = 8.26\ \text{LB}/1000\ \text{FT}^3}$$

NSPS currently require amine scrubbing of the gas to remove H$_2$S prior to combustion to a level equal to 20 gr/100 scf of gas on the basis of SO$_2$.

$$\frac{0.2\ \frac{\text{gr}}{\text{FT}^3}}{7000\ \frac{\text{gr}}{\text{LB}}} \times 1000\ \text{FT}^3 = 0.0286\ \text{LB}/1000\ \text{FT}^3$$

$$\frac{8.26 - .0286}{8.26} = 99\%$$

$$\boxed{E_{NSPS} = 0.0286\ \text{LB}/1000\ \text{FT}^3}$$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hansen Date 1/8/75

Source Petr. Ref - Process Gas Comb

$E_{SO_2\,unc} = E_{unc} = 0.0286\ \text{lb}/1000\ \text{ft}^3\ \text{gas}$

$$\boxed{E_{SO_2\,NSPS} = 0.0286\ \text{lb}/1000\ \text{ft}^3\ \text{gas}}$$

From p4 of these calcs

Texas = 27.3%   Penn = 8.1%
Cal. = 12.8%   Ind = 4.7%
Louis = 10.8%   Ohio = 4.8%
Ill. = 6.6%   NJ = 4.1%

From Ref (71) & (18)

Texas - Ground level conc'n
Cal - 200 gr/100 Ref (76)

$$\frac{\left(\frac{7.5\times10^6\ \text{ft}^3}{\text{day}}\right)}{\left(24\ \frac{\text{hrs}}{\text{day}}\right)} = 3.125\times10^5\ \frac{\text{ft}^3}{\text{hr}}$$

$$\frac{200}{3.125\times10^5}\times1000 = 0.64\ \text{lb}/1000\ \text{ft}^3\ \text{gas}\ *$$

Louisiana 2000 ppm

Ref (44) p 25 0.2 gr/scf of gas burned as 17 ppm SO_2 in the exhaust

$$\frac{.2}{17} = \frac{x}{2000}\quad x = 23.5\ \text{gr}/\text{scf}\quad \frac{23.5}{7000}\times1000 = 3.36\ \text{lb}/1000\ \text{ft}^3\ \text{gas}\ *$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/8/76

Source Ntrl. Gas – Process Gas Comb.

Ill. – Ground level reg for gas

Penn – no reg for gas

Ind. 6 LB/10^6 BTU

$6\times10^{-6}\ \frac{LB}{BTU}\times 1500\ \frac{BTU}{FT^3}\times 1000 = 9\ LB/1000\ FT^3$

Ohio $(1\times10^{-6})(1500)(1000) = 1.5\ LB/1000\ FT^3$

N.J. $(.3\times10^{-6})(1500)(1000) = 0.45\ LB/1000\ FT^3$

$$E_{SO_2\ exist} = (.135)(.64) + (.102)(3.36) + (.047)(9.0) + (.043)(1.5) + (.041)(.45) + E_{SO_2\ exist}(.568)$$

↑ Assumes all other States = to exist. avg

$$E = .0864 + .343 + .423 + .065 + .432E$$

$$E_{SO_2\ exist} = .9174 \div .4326 = 2.12$$

$$\boxed{E_{SO_2\ existing} = 2.12\ LB/1000\ FT^3}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/8/78

Source Petr. Ref - Process Gas Combustion

NOx

Ref (75) p 9.1-3 Tab 9.1-1

$$\boxed{E_{V_{NO_x}} = 0.23 \text{ lb}/1000 \text{ ft}^3}$$

No specific reference to NOx control could be located. However, Ref (248) p 7-6 Fig 35 indicates an approximate reduction of 50% using "optimized design" for natural gas fired "packaged firetube boiler". Using this %,

$$E_{N_{NO_x}} = (1-.5)(.23) = 0.115 \text{ lb}/1000 \text{ ft}^3$$

$$\boxed{E_{N_{NO_x}} = 0.115 \text{ lb}/1000 \text{ ft}^3}$$

From Ref (64) & (65)

$$E_{S_{NO_x}} = 0.2 \text{ lb}/10^6 \text{ BTU} \quad \text{for gaseous fuels}$$

$$0.2 \times 10^{-6} \frac{\text{lb}}{\text{BTU}} \times 1050 \frac{\text{BTU}}{\text{ft}^3} \times 1000 \text{ ft}^3 = 0.2 \text{ lb}/1000 \text{ ft}^3$$

Since this is greater than Ev, Es = Ev

$$\boxed{E_{S_{NO_x}} = 0.23 \text{ lb}/1000 \text{ ft}^3}$$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/8/78

Source Petro. Ref - Process Gas Comb.

HC

Ref ⑮ p 9.1-5 TAB 9.1-1

$E_{U_{HC}} = 0.03 + .003 = .033$ lb/1000 ft³

$$\boxed{E_{U_{HC}} = 0.033 \text{ lb/1000 ft}^3}$$

Since there are no demonstrated controls for H/C emissions, we will purposely set $E_N = 0.0$ as we have done in similar cases.

$$\boxed{E_{N_{HC}} = 0.0}$$

Since there are no HC regs, $E_S = E_U$

$$\boxed{E_{S_{HC}} = 0.033 \text{ lb/1000 ft}^3}$$

CO Ref ⑮ p 9.1-5 indicates negligible emissions

NH_3 Same Ref indicates negligible emissions

Sulfur.

It is assumed that all sulfurs (primarily H_2S) are oxidized to SO_2. Since the Eu-fac SO_2 used this assumption, any sulfurs that might not not have been oxidized were actually "counted" under SO_2 emissions.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 1/8/78

Source Pet. Ref – Process Gas Comb.

See note below

Summary lb/1000 ft³	Eu	EN	[illegible]	
			[illegible]	[illegible]
Pt	.02	0.0	.02	
SO_x	8.26	.0386	2.49	.0286
NO_x	.23	.115	.23	
HC	.033	0.0	.033	

During our analysis of Process Gas Combustion, the use of a wet (H_2O) scrubber was employed to eliminate NH_3 from a process gas stream prior to combustion. Such a device would have the effect of reducing particulate emissions as well. Since we are assuming a transfer of technology, we will choose an efficiency = 85%

$$E_{N_p} = (1-.85)(.02) = 0.003$$

$$\boxed{E_{N_p} = 0.003 \text{ lb}/1000 \text{ ft}^3}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By Hoffman Date 1/8/75

Source Petroleum Refinery - Vacuum Distillation

Ref (44) p 42 ff

The capacity for vacuum distillation (1971) is reported as

$$4.741 \times 10^6 \ \frac{\text{BBLS}}{\text{SD}}$$

$$4.741 \times 10^6 \times 330 = 1.565 \times 10^9 \ \text{BBLS/YR}$$

From previous calculations regarding FCC units ("See "Petroleum Refinery - FCCU - Industrial Factors")

$$\boxed{P_c = 0.0422} \quad \text{compound}$$

$$\boxed{K = 0.85}$$

$$\boxed{P_B = 0.031} \quad \text{simple}$$

Since these values were developed for refineries, in gen'l, they are assumed to be applicable to the vacuum distillation process

$$A = (1.565 \times 10^9)(1 + .0422)^4 = 1.846 \times 10^9$$

$$\boxed{A = 1.846 \times 10^9 \ \frac{\text{BBLS VACUUM DISTILLATE}}{\text{YR}}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/8/75

Source Petroleum Refinery - Vacuum Dist.

Ref ⑦⑤ p9.1-4

$$E_{U_{HC}} = 130 \text{ lb}/1000 \text{ bbl distillate} = 0.130$$

vacuum jets

$$\boxed{E_{U_{HC}} = 0.130 \text{ lb}/\text{bbl distillate}}$$

vacuum jets

Same Ref. indicates negl. emissions if controlled by flare burner. We will assume $\eta = 99.9\%$

$$E_{N_{HC}} = (1-.999)(.130) = 0.0001$$

$$\boxed{E_{N_{HC}} = 0.0001 \text{ lb}/\text{bbl distillate}}$$

There are no regs for HC emissions of this nature. $\therefore E_S = E_U$

$$\boxed{E_{S_{HC}} = 0.130 \text{ lb}/\text{bbl dist.}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By [illegible] Date 1/6/75

Source Petroleum Refinery – Miscellaneous Point Sources

There are many small emission points throughout a petroleum refinery. Singly, they may be quite small – but in the aggregate they could represent a significant quantity of HC emissions. We will treat them as a single class, apply an assumed E_N & determine if NSPS might be warranted.

We have previously developed K, P_C & P_S for refineries. (See "Petro. Refineries – Misc") We will use these same values for the Misc. category

$$\boxed{K = 0.35}$$

$$\boxed{P_C = 0.0422}$$ compound

$$\boxed{P_S = 0.031}$$ simple

Ref ④ p42

1971 Capacity = 12.681×10^6 bbl/sd

$$(12.681 \times 10^6)(330)(1 + .0422)^4 = 4.937 \times 10^9 \frac{\text{bbls}}{\text{yr}}$$

$$\boxed{A = 4.937 \times 10^9 \text{ bbls/yr}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/3/78

Source Petr. Ref. - Misc. Point Sources

Ref ⑮ p 9.1-4,5 Tab 9.1-1 lists the following misc. HC emissions in terms of lb/bbl refinery capacity

Blowdown Systems = 0.300
Vapor recovery system or flaring = 0.005
Process drains = 0.210
Pipeline valves & flanges = 0.028
Vessel Relief valves = 0.011
Pump seals = 0.017
Compressor seals = 0.005
Misc. = 0.010
Σ = 0.586

$$\boxed{E_{U_{HC}} = 0.586 \text{ lb/bbl}}$$

If we assume that "good housekeeping", vapor recovery, etc. can be 50% effective in reducing emissions,

$$E_N = (1-.5)(.586) = 0.293$$

$$\boxed{E_{N_{HC}} = 0.293 \text{ lb/bbl}}$$

Except for storage tank regs, which have been covered elsewhere in this study, there are no applicable regs. So, $E_S = E_U$

$$\boxed{E_{S_{HC}} = 0.586 \text{ lb/bbl}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 10-4-74

Source Sulfur Recovery - Refinery Fuel Gas

This study will be concerned with sulfur recovery by Claus Plants at Refineries treating several H_2S, CS_2 and COS streams. All factors will therefore be based on the Claus plants.

K: Ref 150 pg 92

average capacity factor for refinery Claus plant is about 66%.

$$\boxed{K = .66}$$

A: Ref 150 pg 92 note (c)

Claus sulfur plants are on the average 92% eff in converting H_2S in feed to Sulfur. Average sulfur in [illegible] [illegible] is .92%.

Using the 1975 Claus capacity of 8,167 metric TON/DAY developed on the same page of Ref 150 we may recalculate this "recovered sulfur" capacity into capacity in terms of sulfur feed.

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 10-4-74

Source Sulfur Recovery - Refinery Fuel Gas

15 cont'd

1 metric ton = 1.1023 TON

365 day/year basis

$$\text{1975 Sulfur Feed Capacity TONS/yr} = \frac{\text{1975 Recovery Cap (Metric Tons/day)}}{.92} \times 365 \frac{d}{yr} \times 1.1023 \frac{T}{MT}$$

$$= \frac{8167 \ MT/D}{.92} \times 365 \ D/yr \times 1.1023 \frac{T}{MT}$$

1975 Feed Cap = 3,571,638 TON/yr sulfur feed to Claus

$$\boxed{A = 3.57 \times 10^6 \ \text{TON/yr}} \quad \text{sulfur feed to Claus}$$

It is important to note that the units for A have been developed in terms of sulfur feed to the Claus plant rather than sulfur recovered. The reasoning for this is reflected by the fact that the total sulfur recovered for this industry is tied directly to the overall system efficiency. In this way, the value of A is indirectly a function of the emission factors. This would mean that the 1975 value of "A" (TON/yr sulfur recovered) would apply to

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Massone Date 10-4-74

Source Sulfur Recovery - Refinery Fuel Gas

A: cont'd

an efficiency of 92% when applying E_u however, once we tried to apply increased levels of control $(E_s = E_u)$ we would in fact be artificially changing the value of "A". We have eliminated this problem by making the capacity basis in terms of feed.

P_c : Referring to the Industrial Factor section of "Petroleum Storage & Transfer — Tanks" by Tom Hopper we may abstract the growth factor for crude oil production. We assume the growth factor for crude petroleum is indicative of sulfur recovery. ~~[illegible]~~ Growth = 4.22% compound

$$\boxed{P_c = .042 \text{ compound}}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date

Source Sulfur Recovery - Refinery Fuel Gas

P_B : We assume that depreciation for sulfur recovery plants within petroleum refinery may be estimated by using the asset guideline life for petroleum refineries in general

Ref. 037 pg 31 Section 13.3

Asset guideline period 16 yrs

P_B est $\rightarrow$ 2×IRS = 32 yrs

$\frac{100\%}{32\text{ yrs}} = 3.1\%/\text{yr} \approx 3\%/\text{yr}$ simple

$\boxed{P_B = .03 \text{ simple}}$

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Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 10-4-74

Source Sulfur Recovery - Refinery Fuel Gas

E_u :

Ref 150 "Table 1" pg F-6

Gives the following wt % of sulfide compound in Claus plant (typical) emissions.

	%	MW	% × MW
H_2S	.85 % wt	34	28.9
SO_2	.42 % wt	64	26.9
COS	.05 % wt	60	3.0
CS_2	.04 % wt	76	3.04
S_8	.05 % wt	256	12.8
			74.64

Components by weight percent of sulfur compound present

$H_2S = \frac{28.9}{74.64} = .387 = 38.7\%$

$SO_2 = \frac{26.9}{74.64} = .360$ or 36.0%

$COS = \frac{3.0}{74.64} = .040$ or 4.0%

$CS_2 = \frac{3.04}{74.64} = .041$ or 4.1%

$S_8 = \frac{12.8}{74.64} = .172$ or 17.2%

100% ✓

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Refinery Fuel Gas

Ex. 1 cont'd

Using this weight percent we may state that for a volume of exhaust containing 100 lbs of sulfur compounds we will obtain

38.7 lb H_2S
36.0 lb SO_2
4.0 lb COS
4.1 lb CS_2
17.2 lb S_8
100 lb sulfur compounds

Taking the mw ratio of S to that of each compound we may calculate the lb Sulfur attributable to each individual compound and a total gas stream containing 100 lb of sulfur compounds

	wt S / wt	lb S
H_2S	.941	36.4
SO_2	.500	18.0
COS	.533	2.1
CS_2	.842	3.5
S_8	1.00	17.2
		77.2 lb S

This implies $\frac{77.2 \text{ lb S}}{100 \text{ lb Sulfur compounds}}$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Refinery Fuel Gas

EF: cont'd

eg 36.4 lbs sulfur / 77.2 lbs = .472

Ratioing once again (lbs S in compound / lbs S total) we obtain a % breakdown of sulfur in the total exhaust attributable to each sulfur compound making up the waste stream.

	%S of Total Exhaust attributable to this compound
H_2S	47.2
SO_2	23.3
COS	2.7
CS_2	4.5
S_x	22.3
	100.0 ✓

Assuming, as we did above under Production Capacity-A determination, a 92% sulfur removal in a typical Claus plant then,

100 lb of Sulfur Feed to Claus Plant → 8 lb of Sulfur emitted

or 2000 lb (Ton) of Sulfur Feed to Claus Plant → 160 lb of sulfur emitted.

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Project Number - 3230: New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Refinery Fuel Gas

cont'd

On the basis of a ton of S feed to a Claus plant we will have 160 lb of S being emitted and using the wt % breakdown of S by component we may calculate the emission factors for all sulfur compounds

lb S attributable to:

H_2S .472 × 160 = 75.5

SO_2 .233 × 160 = 37.3

COS .027 × 160 = 4.3

CS_2 .045 × 160 = 7.2

S_x .223 × 160 = 35.7

160 ✓

We will present the emission factors in terms of the two components SO_2 and H_2S (representing sulfide compds)

$37.3 \frac{\text{lb S in } SO_2}{\text{Ton S Feed}}$ and $122.7 \frac{\text{lb S in Sulfides}}{\text{Ton S Feed}}$

$\frac{\text{MW } SO_2}{\text{MW S}} = \frac{64}{32} = 2$ $\frac{\text{MW } H_2S}{\text{MW S}} = \frac{34}{32} = 1.06$

$74.6 \frac{\text{lb } SO_2}{\text{Ton sulfur feed}}$ $130 \frac{\text{lb sulfide}}{\text{Ton sulfur feed}}$ as H_2S

or 75 lb SO_2 ✓/Ton sulfur feed

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Refinery Fuel Gas

E_u: cont'd

summary

E_u

SO_x	75 lb/TON of Sulfur Feed to Claus Plant
Sulfides as H_2S	130 lb H_2S/TON of Sulfur Feed to Claus Plant

Project Number - 32391 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By W. Marrone Date 10-7-74

Source Sulfur Recovery - Refinery Fuel Gas

E_N: Ref 150 pg 92 (7)

"Tail gas processes are, on the average, about 94 percent efficient and thus will raise the overall level of sulfur recovery (Claus plant plus tail-gas process) to about 99.5%, and this represents best available technology."

We will use this value of 99.5% overall sulfur removal efficiency. Referring to pg 41-90 of Ref 150 we see that most of the Tail gas processes reduce the emissions to SO_2 solely.

$$\boxed{\therefore E_N\ H_2S = 0}$$

therefore all sulfur emitted is in form of SO_2

SO_2 Emission

1. Ton Sulfur Feed and 99.5% recovery

$$2000\ lb \times .005 = \frac{10\ lb\ S}{\text{Ton Feed to Claus}}$$

$$\frac{mol\ SO_2}{mol\ S} = \frac{64}{32} = 2/1 \qquad 2 \times 10 = \frac{20\ lb\ SO_2}{\text{Ton S in Feed}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Massone Date 10-7-74

Source Sulfur Recovery - Refinery Fuel Gas

E_N: cont'd

Summary

	E_N
SO_x	20 lb/Ton S Feed to Claus Plant
Sulfides	0 lb H_2S/Ton S Feed to Claus Plan

E_{IIIA}: Sulfides

Tail gas processes are designed to be functional on Claus plants and it should not matter whether the plant is new or existing. We assume that the overall efficiency for existing plants will be identical as for new plants or $E_{IIIA} = E_N$

$$E_{IIIA} = 0 \quad H_2S$$

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Computation Sheet for Emission Factors

Calculations Done By W. Marrone Date 10-10-74

Source Sulfur Recovery - Refinery Fuel Gas

E_5 : Ref 084 Table XVII and update from Ref 118

① Alaska, Colorado, Illinois, Indiana, Kansas, Minn, Missouri, Utah, New Mexico, New York, N. Dakota, and Wisconsin do not have applicable regulation for sulfur recovery plants. We assume $E_{5c} = E_{5u} = .08$ lbs/lbs input (in terms of total sulfur feed)

∴ $E_{5c} = .08$ lbs/lbs input (old & new)

② Arkansas reg is based on ground level SO_2 conc. We assume Ark will have an emission factor based on the avg E_5 to meet the regulation. $E_{5c} = E_5^A$ (old & new)

③ Mich regulation specifies .01 lbs/lbs input for Wayne Co only the state reg appears. According to Ref 180 pg 24-25 69/89 = 78% of capacity is in Wayne Co. We assume 22% has no reg and thus $E_{5c} = E_{5u} = .08$

$$E_{5c} = .78(.01) + .22(.08)$$

$$E_{5c} = .0078 + .0176$$

$$E_{5c} = .025 \text{ lbs/lbs input}$$

(old & new)

④ California has no State regulation, only reg in the 13 counties, We will assume $E_{5c} = E_5^A$ as applicable to Calif. (old & new)

⑤ Delaware and New Jersey specify effluent SO_2 concentrations. We assume both the states to represent the average $E_{5c} = E_5^A$. (old & new)

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Computation Sheet For Emission Factors

Calculations Done By D. Mason Date 10-10-74

Source Sulfur Recovery - Refinery Fuel Gas

E_{s1} cont'd

⑥ Texas specifies a SO_2 lb/hr limitation based on the stack effluents - [illegible]. Ref 149 pg 56 states that Texas law requires an efficiency of 99 & 97% which is equivalent to Louisiana. We use E_{s1} = .01 lbS/lbS input the same as for La. (old & new)

⑦ Pennsylvania regulation is given by $A = .32E^{-.5}$ where E is plant rating in long tons S/day and A in lb SO_2/lb S input

Penn's $\frac{342\ MTD}{5\ plants} = 68.4\ \frac{MTD}{plant}$ 1.106 MTD = 1 LTD or 1 MTD = .904 LTD

$68.4\ \frac{MTD}{plant} \times \frac{.904\ LTD}{1\ MTD} = 61.8\ LTD$

$A = .32\ (61.8)^{-.5}$

$A = .04$ lb SO_2/lb S input

$\frac{MW\ S}{MW\ SO_2} = \frac{32}{64} = \frac{1}{2}$ ∴ A = .02 lb S/lb S input

We therefore have E_{s1} = .02 lbS/lbS input (old & new)

⑧ Utah regulation requires 90% control if emissions S > 250 T/yr

Ref 180 pg 54
1 plant = 12 MTD
180

$\left(12\ \frac{MTD}{plant} \times 1.1023\ \frac{T}{MT}\right) \times \frac{365\ D}{yr} \times \frac{160\ lbS}{Ton\ S\ input} \times \frac{Ton}{2000\ lb} = 326$ T/yr S emitted

sulfur input

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Computation Sheet For Emission Factors

Calculations Done By R.J. Marrone Date 10-10-74

Source Sulfur Recovery - Refinery Fuel Gas

E_S :

⑧ cont'd

Since E > 250 T/yr emissions we apply the 80% control requirement

E_u = .08 lbS/lbS input

E_{SL} = .2 × .08 lbS /lbS input

E_{SL} = .016 lbS / lbS input

⑨

	Old Stds. lbS/lbS input
Louisiana	.01
Ohio	.01
Mississippi	.06
Virginia	.05

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Sulfur Recovery - Refinery Fuel Gas

	Sulfur Cap MTD	Fract. [illegible] Capacity	Allowable % [illegible]
Alabama	—		
Alaska	9	.0011	.08
Arizona	—		
Arkansas	25	.0031	E_o^A
Colorado	19	.0023	.08
California	2,510	.3138	E_o^A
Conn.	—		
Delaware	775	.0969	E_o^A
D.C.	—		
Florida	—		
Georgia	—		
Hawaii	—		
Idaho	—		
Illinois	569	.0711	.08
Indiana	414	.0518	.08
Iowa	—		
Kansas	44	.0055	.08
Kentucky	—		
Louisiana	570	.0713	.01
Maine	—		
Maryland	—		
Mass.	—		
Michigan	89	.0111	.025
Minn.	170	.0213	.08
Miss.	30	.0038	.06
Missouri	80	.0100	.08
Montana	113	.0141	.08
Nebraska	—		
Nevada	—		
N. Hampshire	—		
N. Jersey	617	.0771	E_o^A
N. Mexico	30	.0038	.09
New York	50	.0062	.08
N. Carolina	—		
N. Dakota	200	.0250	.08
Ohio	89	.0111	.01

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Sulfur Recovery - Refinery Flash Gas
cont'd

	Sulfur Cap MTD	Frac Capacity R_i	Allowable R [illegible]
Oklahoma	—		
Oregon	—		
Penn.	342	.0428	.02
R. I.	—		
S. Carolina	—		
S. Dakota	—		
Tennessee	—		
Texas	1,178	.1473	.01
Utah	12	.0015	.016
Vermont	—		
Virginia	50	.0063	.05
Washington	—		
W. Virginia	—		
Wisconsin	15	.0019	.08
Wyoming	—		
TOTAL	7,999	Σ 1.0002	

OK! rounding error

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Project Number - 32391 New Source Perfomance Standards

Computation Sheet for Emission Factors

Calculations Done By W. Manness Date 10-10-74

Source Sulfur Recovery - Refinery Fuel Gas

E_s : cont'd

State	$E_{si} \times A_i$
Alaska	.0009
Arkansas	.0051 E_s^A
Colorado	.0002
California	.3188 E_s^A
Delaware	.0969 E_s^A
Illinois	.0057
Indiana	.0041
Kansas	.0004
Louisiana	.0007
Michigan	.0003
Minnesota	.0017
Mississippi	.0002
Missouri	.0008
Montana	.0011
New Jersey	.0771 E_s^A
New Mexico	.0003
New York	.0005
N. Dakota	.0020
Ohio	.0001
Pennsylvania	.0009
Texas	.0015
Utah	.0002
Virginia	.0003
Wisconsin	.0002

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Massena Date 10-10-74

Source Sulfur Recovery - Refinery Fuel Gas

$$E_S^A = \sum E_{Si} \times A_i$$

$$E_S^A = \sum E_{Si} \times A_i = .0211 + .4909\, E_S^A$$

$$(1-.4909)E_S^A = .0211$$

$$.5091\, E_S^A = .0211$$

$$E_S^A = .041 \text{ lbS/lbS input}$$

We assume the same breakdown of H_2S and SO_2 as shown under E_U determination.

23.3% S (in SO_2) making up of total : .233 × .041 = .0096 lbS/lbS input
76.7% S (in H_2S) making up of total : .767 × .041 = .0314 lbS/lbS input

$\frac{MW\ SO_2}{MW\ S} = \frac{64}{32} = \frac{2}{1}$ $\Longrightarrow$ 2 × .0096 = .0192 lb SO_2/lb S input

$\frac{MW\ H_2S}{MW\ S} = \frac{34}{32} = \frac{1.06}{1}$ $\Longrightarrow$ 1.06 × .0314 = .0333 lb H_2S/lb S input

OR ×2000

$$\boxed{\begin{array}{l} E_S = 38.4 \text{ lb } SO_2\text{/TON S input} \\ E_S = 66.6 \text{ lb } H_2S\text{/TON S input} \end{array}}$$

APPENDIX 4-B

DETERMINATION OF INPUT VARIABLES
FOR
THE WOOD PRODUCTS INDUSTRY

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-20-74

Source Chip Board

K: Assume that the paper industry in general will be gearing to the same supply/demand picture discussed in "Wood Pulping - Kraft" by W. Marrone and that all portions will be operating under the same capacity utilization ratio.

$$\boxed{K = .98}$$

A: Ref 144 pg 8-36

under Paper & Paper Products we obtain 1972 production quantities

as	Paper board	[illegible]	× 10³	tons
	Wet-Machine Board	129	× 10³	tons
	Construction Paper & Board	3,879	× 10³	tons
		55,348	× 10³	tons

Ref 149 pg 14

1.5%/yr capacity growth is predicted for period 1973 - 1985 which we assume will be representative of this industry for 1975 - 1985

$$\boxed{P_c = .015 \text{ compound}}$$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Marrama Date 12-20-74

Source Pulpboard

A: cont'd

$$P_{73} = 35,349,000 \text{ TON/yr}$$

$$P_{75} = P_{73}(1+P_c)^2 = 35.35\times10^6(1+.015)^2$$

$$P_{75} = 36.42\times10^6 \text{ TON/yr pulpboard}$$

$$A = \frac{P_{75}}{K} = \frac{36.42}{.98}\times10^6 = 37.2\times10^6 \frac{\text{TON}}{\text{yr}}$$

$$\boxed{A = 37.2\times10^6 \frac{\text{TON}}{\text{yr}}}$$

P_B: Ref 077 Class 26.1

Asset Guideline period = 16 yrs
P_B est = 2×ADR = 32 yrs

$$\frac{100\%}{32 \text{ yrs}} = 3.1\%/\text{yr simple}$$

$$\boxed{P_B = .031 \text{ simple}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 12-20-74

Source Pulp Board

E_u:

Particulates

Ref. 075 Table 10.2-1

	lb/ton [illegible]
Paperboard	neg
Fiberboard	.6

Not knowing the breakdown of pulpboard (which is paperboard and fiber board), we make the assumption that Ref. 144 5-36 lists "paperboard" as paperboard and "wet-machine board" and "construction paper and board" as fiberboard.

Therefore

$$\frac{5999 + 115}{38,348} = 16\% \text{ for fiberboard}$$

$$\frac{32,234}{38,348} = 84\% \text{ for paperboard}$$

An emission factor is developed which is a weighted average

$$E = .16(.6) + .84(0) = .096 \text{ lb/ton}$$

$$\therefore \boxed{E_u = .096 \text{ lb/ton}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 12-30-74

Source Pulpboard

E_N:

Ref. 075 pg 10.2-1 indicates that the particulate emissions are attributable to drying operations.

Control for this source was not specified nor determined from the literature.

It is conceivable that emissions from the dryer are very low (especially ~~[illegible]~~ in terms of size) so that add-on controls would be impractical and not very feasible.

We make an assumption that a control system can be applied and that 85% efficiency would be attained.

$E_N = .15 * E_u = .15 * .095 = .014$ lb/ton

$\boxed{E_N = .014 \text{ lb/ton paperboard}}$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Massone Date 12-20-74

Source Pulpboard

E_3 1

Particulate

As was determined, the uncontrolled emissions from fiberboard drying is .6 lb/ton product
and our hypothesized emission level is .096 lb/ton product.

Specific information on plant locations, typical plant size, etc was not obtained however by assuming the generalized process weight table applies we may see that this source emits particulate matter in quantities well below the level specified by the Process Weight curve.

By looking at allowable emissions at several points in the GPWC we may establish the lb/ton product allowed

Process Wt Rate lb/hr	lb/hr allowed	lb/ton
50	.03	1.2
100	.53	10.6
1,000	2.50	5.0
10,000	11.50	2.3
100,000	40,00	.8

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-20-74

Source Pulpboard

E_s cont'd

Since we expect the process weight for a paperboard operation to be in the above range and most likely near the 50-1000 range the $E_s > E_u$ in which case we set $E_s = E_u$

E_s = .096 lb/ton pulpboard

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Project Number - 32391 New Source Performance Standards

Computation Sheet for Industrial Factors

Calculations Done By Al Massarano Date 12-30-79

Source Plywood/Veneer

P_c :

Ref 196 p53-55

1978 production softwood plywood 18.2 ×10⁹ sqft

Ref 245 pg 63 states that hardwood and softwood for past [illegible] decades growth mainly due to softwood production. compound growth rate in the period 1978-1980 is expected to average 2.1 to 2.9 percent with 1980 output at approximately 21 to 22 ×10⁹ sq ft

We make an assumption that the simple arithmetic average growth (2.45%) rounded to 2.5% would apply this industry.

assume hardwood too [illegible] for negligible effect on overall growth

$\therefore P_c = .025$ compound

K: Ref 196 p 54

1978 production of 18.2×10⁹ sqft was about 95% of nominal capacity.

Capacity utilization is assumed to be equivalent for hardwood and softwood plywood and that the factor of 95% in 1978 is representative.

K = .95

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. [illegible] Date 12-30-74

Source Plywood/Veneer

A:

Using data in Table 295 pg 62-63

P_{69} Hardwood Plywood 2×10^9 sqft

P_{72} " " 2.2×10^9 sqft

" Hardwood plywood production fairly constant over past 20 yrs."

We will assume hard wood production will grow at same rate as softwood eventhough growth appears negligible

$P_{73} = P_{72} = 2.2 \times 10^9$ sqft hardwood plywood

$P_{73} = 18.2 \times 10^9$ sqft softwood plywood

$P_{73} = 20.4 \times 10^9$ sqft plywood

$$P_{75} = P_{73} (1 + P_a)^n$$

$$P_{75} = 20.4 \times 10^9 (1.025)^2 \cong 21.5 \times 10^9 \text{ sqft}$$

$$A = \frac{P_{75}}{K} = \frac{21.5 \times 10^9}{.95} = 22.6 \times 10^9$$

$$\boxed{A = 22{,}600 \times 10^6 \text{ sq ft}}$$

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Project Number - 3290 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. [illegible] Date 12-30-74

Source Plywood/Veneer

P_B:

Ref 037 Class 24.4

Asset Guideline Period 10 yrs

P_B est ≈ 2 × AGP 20 yrs

$\frac{100\%}{20 \text{ yrs}}$ = 5%/yr simple

$\boxed{P_B = .05 \text{ simple}}$

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Project Number - 32301 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By [illegible] Date 12-30-77

Source Plywood Veneer

Particulate

Ref 248 Table 8 pg 77

E_u: exclude power boiler, teepee burner (waste disposal) emissions]

Emissions from Sanding Operation 33-99 Tons/10^6 sq ft

We will use the arithmetic average 66 Tons/10^6 sq ft

$$66 \frac{\text{Tons}}{10^6 \text{ft}^2} \times 2000 \frac{\text{lb}}{\text{Ton}} \times 10^{-6} = .132 \frac{\text{lb}}{\text{ft}^2} \text{ plywood}$$

$$\boxed{E_u = .132 \text{ lb/ft}^2 \text{ plywood}}$$

E_N: Control for plywood sanding was not explicitly given. Ref 017 pg 115 stated that cyclones may be applied to this operation with efficiency about 90%.

It is suspected that baghouses could be applied easily and an assumed efficiency of 99% be achieved

$E_N = .01 \times E_u = .0013$ lb/ft² plyw

$$\boxed{E_N = .0013 \text{ lb/ft}^2 \text{ plywood}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Marrone Date 12-30-74

Source Plywood / Veneer

Particulate cont'd

E_p'

Ref 245 pg 62

In 1968

175	softwood Plants	14×10^9 sq ft
242	hardwood	3×10^9 sq ft
417	Plants Total	17×10^9 sq ft/yr

$$\text{Average Plant Size} = \frac{17 \times 10^9}{417} = 40.76 \times 10^6 \text{ sq ft/yr}$$

Assume Plant Schedule $16 \frac{\text{hr}}{\text{day}} \times 350 \frac{\text{d}}{\text{yr}} = 5600 \frac{\text{hr}}{\text{yr}}$

Board Size 3/8" thickness (.375")

Density referring to Table 10% pg 23-68 to 23-69

for softwoods: range specific gravity .32 - .66

use .50

$$\text{density} = .5 \times 62.4 \frac{\text{lb}}{\text{ft}^3} = 31.2 \frac{\text{lb}}{\text{ft}^3}$$

$$\text{Process wt Rate} = \frac{.375 \text{ in}}{12 \frac{\text{in}}{\text{ft}}} \times 40.76 \times 10^6 \frac{\text{ft}^2}{\text{yr}} \times \frac{\text{yr}}{5600 \text{ hr}} \times 31.2 \frac{\text{lb}}{\text{ft}^3} \approx 7097 \frac{\text{lb}}{\text{hr}}$$

$$\text{use PWR} = 7100 \frac{\text{lb}}{\text{hr}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Meamans Date 10-30-74

Source Plywood / Veneer

Particulate cont'd

E_s: Ref 148 & 80 gives areas for each state.

Ref 215 Table D-1 in App B gives Plywood/Veneer Plants by State.

Taking the number of plants by state that have Plywood & Veneer production and subtracting the plants that do [illegible] we obtain a corrected number which represents the total plants by state in Plywood/Veneer Plants. Using the allowable emissions for each state (P_{wt} = 7100 lb/hr) and the values of A_i we may calculate $E_s = \Sigma E_{si} \cdot A_i$

P_{wt} = 7100 lb/hr

$$E_s = \Sigma E_{si} \cdot A_i$$

assuming that the number of plants in each state has on the average the representative process wt rate and thus we may represent the production distribution by state by the distribution of no of plants.

and;

$$\text{Max Emis } \frac{lb}{ton} = \frac{lb/hr \text{ Allow}}{lb/hr \text{ Process wt}} \cdot 2000 \frac{lb}{ton}$$

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Computation Sheet For Emission Factors

Calculations Done By D. Mazzone Date 12-30-74

Source Plywood/Veneer

Particulate contd

E_3:

State	No. Plants	Pi	lb/ton Weighted Value	Pi × Allow
Alabama	17	.0361	2.20	.0794
Arkansas	13	.0276	2.18	.0602
Arizona	1	.0041	1.85	.0076
California	29	.0616	2.29*	.1409
Colorado	1	.0021	2.19	.0046
Florida	5	.0110	2.35	.0283
Georgia	16	.0340	2.68	.0911
Idaho	5	.0106	2.69	.0289
Illinois	2	.0042	2.69	.0113
Indiana	19	.0403	2.69	.1090
Iowa	2	.0042	2.68	.0113
Kentucky	4	.0084	2.69	.0225
Louisiana	19	.0397	2.00	.0796
Maine	4	.0084	2.20	.0188
Maryland	3	.0069	2.31	.0149
Michigan	8	.0170	2.69	.0493
Minnesota	4	.0084	2.68	.0229
Mississippi	15	.0318	2.68	.0992
Missouri	2	.0042	2.69	.0113
Montana	4	.0084	2.68	.0225
New Hampshire	2	.0042	2.69	.0113
New Jersey	2	.0042	4.75	.0355
New York	7	.0149	2.42	.0360
North Carolina	55	.1155	2.61	.3019
Ohio	2	.0042	2.69	.0113
Oklahoma	1	.0021	2.69	.0056
Oregon	120	.2549	1.80	.2860
Pennsylvania	9	.0191	**	.0191 × 2.000
South Carolina	26	.0552	2.68	.1479
Tennessee	6	.0127	2.68	.0340
Texas	12	.0255	3.04	.0775

Cont'd.

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Project Number: 481 New Source Performance Standards
Computation Sheet For: Emission Factors
Calculations Done By: W. Massena Date: 12-30-74
Source: Plywood/Veneer

Particulate E_i cont'd

State	No. Plants	P_i	lb/ton Allowable Emission	P_i × Allow.
Vermont	6	.0127	2.30	.0292
Virginia	19	.0403	2.68	.1080
Washington	10	.0212	+	.0212 · E_w
West Virginia	3	.0064	1.97	.0126
Wisconsin	22	.0467	2.14	.1019
Total	471			

* used the 1% eq. 29 [illegible] Rules
** E_{avg} in terms of same $E_{si} = E_{avg}$
+ E_{avg} not appear $E_{si} = E_w$

$$E_{avg} = \sum E_{si} \times P_i$$

$$E_{avg} = 2.599 + .0191\,E_{avg} + .0212\,E_w$$

$$(1 - .0191)\,E_{avg} = 2.599 + .0212\,E_w$$

NOTE:

E_w = .152 $\frac{gr}{ft^3}$ × $\frac{18\ [illegible]}{[illegible]}$ × $\frac{[illegible]}{[illegible]}$ × $\frac{[illegible]}{[illegible]}$ = 271 lb/ton

$$E_{avg} = \frac{2.599 + .0212(271)}{.9809}$$

$$E_{avg} = 8.5 \text{ lb/ton}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By DJ Massara Date 1-2-78

Source Plywood / Veneer

Particulate E_s month

E_s = 9.1 lb/Tons × ton/month × [illegible] × [illegible] = .004 lb/sq ft

E_s = .004 lb/sq ft

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Manning Date 1-3-78

Source Plywood / Veneer

Hydrocarbons

Ref 245 pg 77 Table 8

E_u: Emission is HC 5-10 lb/10,000 ft² plywood

We use arithmetic ave 7.5 lb/10,000 ft² plywood

E_u = .00075 lb/ft² plywood

E_N: The emission from the veneer dryer are reported (Refs 170, 968) to be 63% condensible and 37% volatile.

The above references describe a control device which condenses the exhaust stream mainly to diminish the "blue-haze" visible emission. Overall maximum eff. 80%.

Incineration should effectively destroy the volatile compounds. We assume that 99% efficiency may be achieved for veneer dryer HC control.

$E_N = .01 \cdot E_u = .0000075$ lb/ft² plywood

E_S: Regulation applicable to veneer dryers (094, 177) do not exist so that $E_S = E_u$

E_S = .00075 lb/ft² plywood

1 of 4

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By D. Mazzone Date 12-18-74

Source Wood Pulping - Kraft (Sulfate)

K:

Ref. 199 pg 34-35

Discusses the expected condition in the industry of domestic supply less than demand in the future.

Inability of this industry to attract capital for capacity expansion might seemingly [illegible] continue this condition. Capacity utilization will be hard pressed to operate near ability. On pg 35 the industry's average operating rate was 96% for 1973 and the prediction for 1974 was for 100% to be pushed and exceeded.

We will assume that the trend predicted will definitely require capacity utilization greater than 95% and at times near 100%. We choose a value of 98% (near the average of the range) as representative of this industry.

$K = .98$

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By D. Massrone Date 12-18-74

Source Wood Pulping - Kraft (Sulfate)

A1 Ref 0117 pg 109

Production breakdown by process type for 1968

	10^3 tons/day	% of Total
Mechanical	9,100	15.6%
Kraft (Sulfate)	37,500	64.1%
Sulfite	3,900	6.6%
Neutral Sulfite Semichem	5,400	9.2%
Other	2,700	4.5%

Ref 109 pg 1-1 also gives figures which appear to be identical

Ref 994 pg 5-36

Woodpulp production figures 1972 & 1973

	(1972)		(1973)	
Process	10^3 tons	%	10^3 tons	%
Sulfate (Kraft)	31,826	67.1	33,960	67.8
Sulfite	2,178	4.6	2,093	4.2
Groundwood, refiner [Rcd]	7,191	15.5	7,909	16.2
Semichemical (NSSC)	3,971	8.5	4,003	8.3
Other	1,696	3.5	1,672	3.5
Total	46,767		49,638	

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By D. Marrone Date 12-18-74

Source Wood Pulping - Kraft (Sulfate)

A: cont'd

Ref 199 pg 34-35 gives a projected growth rate in wood pulp production of 1.2%/yr which we assume representative of the kraft process (all other process also = which makes the intrinsic assumption that the production % remain constant)

$$\therefore P_c = .012 \text{ compound}$$

Taking the 1973 kraft production from data in Ref [illegible] pg 5-16 (process page) and the values of P_c and K above we may calculate the 1975 production capacity

$$P_{75} = P_{73}(1+P_c)^n$$

$$= 32{,}460{,}000 \frac{TN}{yr}(1+.012)^2$$

$$P_{75} = 33{,}244{,}000 \text{ TN/yr pulp}$$

$$A = \frac{P_{75}}{K} = \frac{33{,}244{,}000}{.98} = 33{,}922{,}000$$

$$A = 33{,}922{,}000 \text{ TN/yr}$$

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Computation Sheet For Industrial Factors

Calculations Done By W. Massoma Date 12-18-74

Source Wood Pulping - Kraft (Sulfate)

A: cont'd

and then combining $A = 33.9 \times 10^6$ tons/yr wood pulp

P_8: Ref 037 Class 26.1 pg 32

Asset guideline period = 16 yrs

P_8 est → 2 × [illegible] = 32 yrs

$\frac{100\%\ \text{depreciation}}{32\ \text{yrs}}$ = 3.1%/yr simple

P_8 = .031 simple

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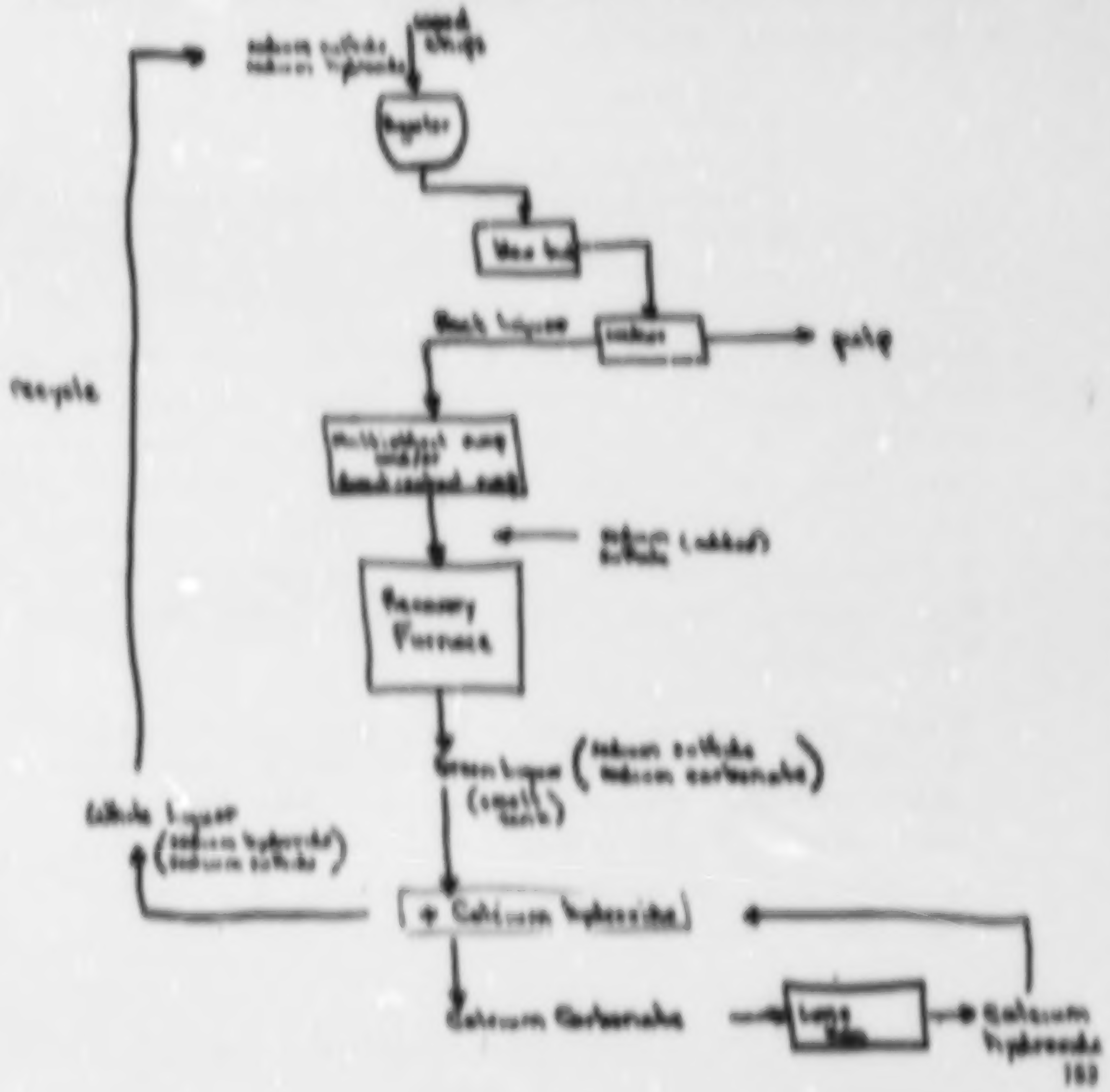
Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Massarone Date 12-18-74

Source Wood Pulping - Kraft (Sulfate)

Generalized Representation of Kraft (Sulfate) Process:


wood chips
sodium sulfide
sodium hydroxide
Digester
Washer
Black liquor
Screen
pulp
recycle
multi-effect evaporator
and/or
direct contact evap
sodium sulfate (added)
Recovery Furnace
Green liquor (sodium sulfide, sodium carbonate)
(smelt tank)
White liquor (sodium hydroxide, sodium sulfide)
+ Calcium hydroxide
Calcium Carbonate
Lime Kiln
Calcium hydroxide

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Massone Date 12-19-74

Source Wood Pulping - Kraft (Sulfate)

The emissions from this industry are generally attributable to the following sources;

① blow tanks
② washers & screens
③ multi-effect evaporator
④ recovery furnace w/or w/o direct contact evaporator
⑤ smelt tank
⑥ lime kiln

Actual emissions, whether considered controlled or uncontrolled, are highly dependent on the mill design and operating conditions. In essence, the last four sources above are process units which are concerned with byproduct recovery and to a lesser degree - emissions control. Reclamation of materials essential to pulping liquors has made the recovery design so integral with the Kraft pulping process.

Since emissions vary greatly from plant to plant due to inherent differences in plant design and practices and control measures employed often times are not add-on but rather process modifications then a different approach to specifying E_u and E_c for this industry will be taken.

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 12-19-74

Source Wood Pulping - Kraft (Sulfate)

E_u:

Uncontrolled emissions will be considered to be those emissions representative of most kraft mills which employ the above processes. Emissions are also considered before any add-on control system.

Ref 075 Table 10.1-1

Emission Table E_u

			lb/ton pulp	
Source	Particulate	SO_2	CO	Sulfide
Blow Tank	—	—	—	3.10
Washers & Screens	—	—	—	.22
Multi-effect Evap	—	—	—	.90
Recovery Furnace & Direct Cont Evap	151.0	5.0	60	12.90
Smelt Tank	2.0	—	—	.07
Lime Kiln	45.0	—	10	1.60
	198.0	5.0	70.0	18.79

$\therefore$

E_u (Part) = 198 lb/ton pulp

E_u (SO_2) = 5 lb/ton pulp

E_u (CO) = 70 lb/ton pulp

E_u (Sulfide) = 18.8 lb/ton pulp

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Project Number - 32191 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Massarne Date 12-19-74

Source Wood Pulping - Kraft (Sulfate)

E_u cont'd Ref 187 pg 12-16

hydrocarbons are attributable to the following sources

	lb/day		
	Acetone	Methanol	Alpha-Pinene
Digester Blow Gas	13	27	118
[illegible] Evaporator	neg	neg	neg
Condensate off-Gas	—	50	20
Black liquor Oxid. off Gas	85	708	91
Washer hood vent	25	92	116
Washer seal tank vent	11	146	715
Knotter hood vent	14	95	20
TOTAL	148	1118	1080

$$E_u = \frac{148 + 1118 + 1080 \text{ lb/day}}{500 \text{ ton/day}} = \frac{2346}{500} = 4.69 \frac{\text{lb}}{\text{ton pulp}}$$

$$\boxed{E_u^{(HC)} = 4.69 \text{ lb/ton pulp}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By 2J Marrone Date 12-19-74

Source Wood Pulping - Kraft (Sulfate)

E_H :

Control of kraft mills involves particulate, odor, economy strategies which many at times they are against the other. We have chosen to assess control impact on this industry by considering the achievable emission levels through the utilization of the best technology for total pollutants from a kraft plant.

Ref 187 pg 9-18

Describes the emissions for a new kraft mill incorporating the latest technological developments in odor (sulfide) and dust control. 800 T/day pulp

The overall system consists of:

(1) high efficiency black liquor oxidation
(2) non-condensible gas burning
(3) stripping and burning of gas from condensate
(4) high efficiency electrostatic precipitators and wet scrubber on recovery furnace
(5) Venturi scrubber on lime kiln
(6) smelt dissolver tank is equipped with demister

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Computation Sheet For Emission Factors

Calculations Done By W. Masrene Date 12-19-74

Source Wood Pulping - Kraft (Sulfate)

E_M : cont'd

Ref 187 pg 17 Table III

Sulfide From this well designed plant = 643 lb/day discharged after all control option

$$E_M(\text{sulfide}) = \frac{643\ \text{lb/day}}{500\ \text{ton/day}} = 1.29\ \text{lb/ton pulp}$$

$$\boxed{\therefore E_M(\text{sulfide}) = 1.29\ \text{lb/ton pulp}}$$

Particulate

Ref 187 pg 16-17

	controlled	
Recovery Furnace	651 lb/day	[illegible]
lime kiln	2000 lb/day	[illegible] scrubber
smelt tank	166 lb/day	
	2817 lb/day	

$$E = \frac{2817\ \text{lb/day}}{500\ \text{ton/day}} = 5.63\ \text{lb/ton}$$

$$\boxed{\therefore E_M(\text{part}) = 5.63\ \text{lb/ton pulp}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D.J. Massoni Date 12-19-74

Source Wood Pulping - Kraft (Sulfate)

E_H cont'd

SO_2:

Ref. 107 pg 14 Table V

For the program shown the SO_2 emission from the recovery furnace and direct contact evaporator during [illegible] black liquor oxidation ranged between 404 - 1300 lb/day. The average is about 800 lb/day with controlled plants

$$E_H = \frac{800 \frac{lb}{day}}{500 \frac{TON}{day} \text{pulp}} \cong 1.6 \text{ lb/ton}$$

$$\boxed{E_H = 1.6 \text{ lb/ton pulp}}$$

Project Number - 32201 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By D. Mascone Date 12-19-77

Source Wood Pulping - Kraft (Sulfate)

E_{HC}: cont'd

Hydrocarbon

Ref. 187 pg 10 Table XIII

After control of digester blow gas noncondensible evaporator off-gas and condensate off-gas, the emissions remaining are

185 lb/day Acetone
1041 lb/day Methanol
892 lb/day Alpha Pinene
2118 lb/day total

$$E = \frac{2118}{500} = 4.24 \text{ lb/ton pulp}$$

This does not represent a significant reduction in hydrocarbon emissions (E_{HC} = 4.69 lb/ton pulp)

We noted that the feasibility of controlling these sources and specifically hydrocarbon components has not been proven.

$$\boxed{E_{HC} = 4.24 \text{ lb/ton pulp}}$$

Project Number - 12391 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By R.J. Marrone Date 12-19-79

Source Wood Pulping - Kraft (Sulfate)

E_H' cont'd

CO

Ref 102 pg 4-24 & 4-25

If sufficient air is supplied in the recovery furnace and the furnace is operated as designed the negligible CO will be emitted.

CO controls for lime kilns are not given however proper kiln operation and design will reduce CO emissions.

We will assume that the recovery furnace may be completely controlled by improved design and operation and that kilns will attain at least a 50% reduction.

$$E = \frac{100-100}{100}\left(60 \tfrac{lb}{ton}\right) + \frac{100-50}{100}\left(10 \tfrac{lb}{ton}\right)$$

$$E = 0 + 5 = 5 \text{ lb/ton}$$

$$\boxed{E_H = 5 \text{ lb/ton pulp}}$$

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Project Number - 32391 Re: Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 12-19-79

Source Wood Pulping - Kraft (Sulfate)

E_{md} :

Sulfide.

As we discussed, controls on the kraft process are attained mainly through plant modification (new plant design utilizing latest technological developments). It may be impractical in many instances for existing plants to incorporate this new technology without complete overhaul.

Process changes may be instituted which would decrease sulfide emissions as well as add-on control system.

Data on existing plant control was not obtained however we make the assumption that the achievable control on existing plants will be near the average of an uncontrolled and a controlled plant.

$$E_{md} = \frac{E_u + E_c}{2} = \frac{19.75 + 0.33}{2} = 10.04$$

$$\boxed{E_{md}^{(\text{sulfide})} = 10.0 \text{ lb/ton pulp}}$$

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R.J. Marrero Date 10-19-74

Source Wood Pulping - Kraft (Sulfate)

E_s :

Ref: 118-084

Regulations specific to hydrocarbons and so do not apply to this industry ∴ $E_s = E_u$

$E_s(uc) = 70$ lb/ton pulp

$E_s(ac) = 4.69$ lb/ton pulp

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Project Number - 32301 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By W. Massarra Date 2-9-78

Source: Wood Pulping - Kraft (Sulfate)

A listing was not found of Kraft production by state nor a total listing of states having Kraft capacity. The only indication of Kraft location is by referring to Ref. 0814 § 149 which specifies actual state regulations (Particulate, SO_2, Sulfides). If we assume that all the states identified represent the majority of Kraft producing states then we may synthesize E_S emission factors by treating each state equally and averaging allowable emission levels.

The list of States identified is as follows:

	Part.	SO_2	Sulfides
Alabama	✓	✓	
Florida	✓		✓
Idaho	✓		✓
Kentucky		✓	✓
Louisiana	✓	✓	
Maine	✓		
Michigan	✓		✓
Montana			✓
New Hampshire	✓	✓	✓
New Mexico	✓		✓
Ohio		✓	
North Carolina	✓		
Oklahoma		✓	
Oregon	✓		✓
Pennsylvania	✓		
South Carolina	✓		
Virginia	✓		
Utah	✓		
Texas	✓		

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By RJ Massone Date 8-4-78

Source Wood Pulping - Kraft (Sulfate)

The following will be used in calculating E_s values

(a) States with no particulate reg. specific to Kraft will use process weight table to determine allowable

(b) From Ref [illegible] 891:0015 [illegible] E_u [illegible] air dry pulp [illegible] for 1 ton pulp and 500 lb [illegible] for 1 ton pulp

(c) States not having SO_2 or Sulfide applicable will be assumed to have $E_{si} = E_u$

(d) Some states have Total Sulfide limitations which we assume will regulate SO_2 and Sulfides. From $E_u(SO_2)$ and E_u(sulfide) we see;

	E_u(lb/ton pulp)	lb S/ton pulp	% S of total
SO_2	5.0 lb/ton	2.5	11.7
Sulfide	18.8 lb/ton	18.8	88.3
		21.3	

We will assume that if a total S regulation is stated then it is applied so that 11.7% is for S (SO_2) and 88.3% as S (sulfides)

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Massaro Date 4-4-78

Source (Wood Pulping - Kraft (Sulfate))

E_{ai} : Allowable Emission Summary Table

State	Particulate lb/ton ADP	SO2 lb/ton ADP	Sulfide lb/ton ADP
Alaska	2.0	5+	19.8
Florida	3.0	5	.5
Idaho	5.5	.12*	6.33*
Kentucky	1.5 **	.12*	6.33*
Louisiana	5.5	5+	19.8
Maine	5.5	5	19.8
Mississippi	5.5	.5*	7.7*
Montana	1.5 **	.05*	6.1*
New Hamp	5.5	.12*	6.33*
New Mexico	5.5	.05*	6.07*
Ohio	1.5 **	5+	19.8
North Carolina	5.5	5	19.8
Oklahoma	1.5 **	2.1	7.9
Oregon	5.5	.12*	6.33*
Pennsylvania	— ***	5	19.8
South Carolina	4.75	5	19.8
Virginia	5.75	5	19.8
Tenn.	5.5	5	19.8
Wash.	7.5	5	19.8

* Limited to recovery furnace only

+ reg exceeds E_u ∴ $E_{ai} = E_u$

** Using P&R curve for state (Ref. 001, 198) and 1/2 to 100,000 weight rate (see next page)

*** assumed equal to average since regulation does not easily apply to overall kraft.

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Massena Date 2-8-73

Source Wood Pulping : Kraft (Sulfate)

E_B' cont'd

Ref. 243 pg 5 1969 data

Kraft mills 116
Production 29.6 × 10⁶ TON pulp

Avg size = 255,170 TON/yr pulp per plant
with 8760 hr/yr → = 29. TON pulp/hr

Assume ≈ 3500 lb solids weight/TON pulp
assuming 8760 hr/yr then we may estimate average process weight rate for average Kraft plant.

$$\text{Avg P.W.R.} = 3500 \frac{\text{lb sol}}{\text{TON pulp}} \times \frac{\text{yr}}{8760\ \text{hr}} \times 255{,}170 \frac{\text{TON pulp}}{\text{yr}}$$

$$= 101{,}951\ \text{lb/hr} \qquad \approx 50.98\ \text{Tons/hr}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrs Date 8-5-75

Source Wood Pulping – Kraft

E_s cont'd

We may now calculate E_s for PT, SO_x and Sulfides by taking the average value for each from the table on pg 14

Particulate

$$\cancel{\boxed{E_s = \frac{\Sigma X_s}{18} = \frac{73.5}{18} = 4.1 \text{ lb/ton pulp}}}$$

We see that $E_s < E_N$ which implies that this pollutant is stringently controlled in this industry. E_s is assumed in reality to be no less than E_N or in fact $E_s = E_N$

$$\boxed{E_s \text{ (PT)} = 5.63 \text{ lb/ton pulp}}$$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 2-5-75

Source Wood Pulping - Kraft

E$_s$ Cont'd

SO$_x$:

$$\boxed{E_s = \frac{\Sigma E_{si}}{19} = \frac{58.16}{19} = 3.06 \text{ lb/ton pulp}}$$

Sulfide:

$$\boxed{E_s = \frac{\Sigma E_{si}}{19} = \frac{241.6}{19} = 12.7 \text{ lb/ton pulp}}$$

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Computation Sheet for Industrial Factors

Calculations Done By W. Marrone Date 12-18-74

Source Wood Pulping - Sulfite

K:

All pulping processing will be assumed equally affected by predicted supply/demand trends so that the K developed for Kraft Plants is considered representative of all Pulp Plants

$K = .98$

P_c:

As discussed under "Wood Pulping - Kraft" pg 3 Ind Factors by W. Marrone

$P_c = .012$ compound

P_B:

Data "Wood Pulping - Kraft" pg 4 Ind Factor

$P_B = .031$ simple

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Computation Sheet For Industrial Factors

Calculations Done By D. Massoni Date 12-18-74

Source 2) Wood Pulping - Sulfite

A:

Using the 1973 production for sulfite wood pulp shown on pg 2.34 of "Wood Pulping - Sulfite" and K, P_a we may calculate the 1975 production capacity for sulfite wood pulp.

$$P_{75} = P_{73}(1+P_a)^2$$

$$= 2,293,000 \frac{TON}{yr} (1+.012)^2$$

$$P_{75} = 2,348,000 \ TON/_{yr}$$

$$A = \frac{P_{75}}{K} = \frac{2,348,000}{.98} \cong 2,396,000 \ TON/_{yr}$$

$$\boxed{A = 2.40 \times 10^6 \frac{TON}{yr} \text{ wood pulp}}$$

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Computation Sheet for Emission Factors

Calculations Done By W. Mascone Date 12-20-74

Source Wood Pulping - Sulfite

Emissions from this industry are not well defined especially since there are a wide variety of plant designs and process types. There are four basic sulfite base systems (magnesium, calcium, ammonia, sodium) Recovery is not always attractive in this industry (not practical) as it is in Kraft Pulp.

"The emission both controlled and uncontrolled will be determined based on information in Ref 196 and 235.

Ref 243 pg 71 a plant not practicing any recovery or liquid burning would have only blow tank and dump tank SO_x emissions

BT 100-150 lb/ton = 125
DT 11-25 lb/ton = 18
143 lb/ton

Ref 243 pg 75

7 + 8 + 6 = 21 plants were surveyed

4 had a recovery furnace

1 + 2 disposed of liquid stream

We will assume that $\frac{5}{21}$ = 24% operate recovery systems

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-30-74

Source Wood Pulping - Sulfite

Eu':

Ref 196 Table 1 pg 101

lb/ADT

	Part	SO_2
Recovery Furnace	2-4	12
Digester Blow	—	10-15
	3	≈ 24

pg 101 states that the SO_2 emissions from this process is about an 80% reduction from calcium based process emissions which generally has no recovery.

$E'_u(SO_2) = \frac{24}{.2} = 120$ lb/ton pulp

pg 100 recovery of dust from recovery furnace is 97% eff

$E'_u(\text{part}) = \frac{3}{.03} = 100$ lb/ton pulp

Particulate

24% will emit 100 lb/ton (from recovery)
76% will emit 0

$E_u = .24(100) + .76(0) = 24$ lb/ton

$\boxed{E_u(\text{part}) = 24 \text{ lb/ton pulp}}$

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-20-74

Source Wood Pulping - Sulfite

E_u: cont'd

SO_x

24% Digester only 143 lb/ton

76% "controlled" by system 120 lb/ton

$E_u = .24(143) + .76(120) = 34.32 + 91.20 = 125.5$

$E_{(u)} = 126$ lb/ton pulp produced

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 12-26-74

Source Wood Pulping - Sulfite

E_N :

Particulate

Ref 196 p 101

Based on results of tests on new magnefite pulping mill utilizing chemical recovery and source controls

Emission from controlled recovery furnace = 3 lb/ton
≈ 3

E_N = 3 lb/ton pulp

SO₂

Ref 196 p 101

states that this mill (designed to meet air pollution regulations) will attain total SO_2 emission from the mill of 20 lb/ton by 1975

$E_N^{(75)}$ = 20 lb/ton pulp

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Computation Sheet For Emission Factors

Calculations Done By W. Massone Date 4-3-75

Source Wood Pulping - Sulfite

Particulates

E_s 1

From ref 243 pg 5 for 1969 there were reportedly 38 mills and 3×10^6 TON/yr production

$$\frac{3 \times 10^6 \ \frac{\text{TON}}{\text{yr}}}{38 \text{ mills}} = 78.95 \times 10^3 \ \frac{\text{TON}}{\text{yr}} \text{ per plant}$$

assuming 24 hr × 7 d × 50 wks = 8400 hr/yr

$$\text{Avg Plant} = 78.95 \times 10^3 \ \frac{\text{TON}}{\text{yr}} \times \frac{\text{yr}}{8400 \text{ hr}} \times \frac{2000 \text{ lb}}{\text{TON}} = 18.8 \times 10^3 \ \frac{\text{lb}}{\text{hr}} \text{ pulp produced}$$

3000 lb solids/TON pulp

using the [illegible] Reg (Ref 148) "891.0811" which was used for Kraft Pulping and use solids content of spent liquor per ton of pulp, we may estimate the process weight rate upon which allowable emissions are determined

$$\text{Avg PWR} = 18.8 \times 10^3 \ \frac{\text{lb pulp}}{\text{hr}} \times \frac{\text{TON pulp}}{2000 \text{ lb}} \times \frac{3000 \text{ lb solids}}{\text{TON pulp}}$$

$$\text{Avg PWR} = 28.2 \times 10^3 \ \text{lb/hr solids}$$

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Project Number - 32381 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Mezzena Date 2-3-79

Source Wood Pulping - Sulfite

Particulate

E_S:

With a lack of information on production of sulfite pulp by state we will estimate the allowable emissions from the Generalized Process Weight Rate Curve:

Allowable Emission Rate = 23.5 lb/hr

For an average plant of 18.8×10^3 lb pulp/hr we determine:

$$E_S = \frac{23.5 \text{ lb/hr}}{18.8 \times 10^3 \frac{\text{lb pulp}}{\text{hr}} \cdot \frac{\text{TON}}{2000 \text{ lb}}} = 2.5 \text{ lb/TON pulp produced}$$

We see that E_S is slightly less than E_H which would imply an industry which is apparently fair highly controlled on the basis of a PWR curve. We change the value of E_S so that it is equivalent to E_H since controls should not be set more stringent than existing technology. ($E_S = E_H$)

$$\boxed{E_S = 3 \text{ lb/TON pulp}}$$

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 2-3-75

Source Wood Pulping - Sulfite

SO_x /

E_s :

Ref: [illegible]

There are no state regulations applicable to SO_x emissions from sulfite pulping processes. In this case we assume $E_s = E_u$

$E_s = 126$ lb/ton pulp produced

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By D. Mazzarone Date 12-18-74

Source Wood Pulping – Neutral Sulfite-Semichemical

K:

The capacity utilization ratio for Neutral Sulfite-Semichemical is assumed to be the same as Kraft and Sulfite Plants

Ref. "Wood Pulping - Kraft"
"Wood Pulping - Sulfite"

K = .98

P_c:

As discussed under "Wood Pulping - Kraft" pg 3 See Factor by [illegible]

P_c = .012 compound

P_B:

Ref "Wood Pulping - Kraft" pg 4 See Factors

P_B = .031 simple

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Computation Sheet For Industrial Factors

Calculations Done By W. Marrone Date 12-18-79

Source Wood Pulping - Neutral Sulfite Semichemical

A:

Using the 1978 production of NSSC wood pulp shown on pg 3 Sec B. of "Wood Pulping - Kraft" and K_1, P_c we may calculate the 1979 production capacity for NSSC wood pulp

$$P_{79} = P_{78}\,(1+P_c)^1$$

$$= 4,089,000\ \tfrac{ton}{yr}\ (1+.003)^1$$

$$P_{79} \cong 4,100,000\ \text{ton/yr}$$

$$A = \frac{P_{79}}{K_1} = \frac{4,100,000}{.98} = 4,183,000\ \text{ton/yr}$$

$$\boxed{A = 4.18 \times 10^6\ \text{ton/yr wood pulp}}$$

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Project Number - 32301 New Source Performance Standards

Computation Sheet for Emission Factors

Calculations Done By D. Massaro Date 12-20-74

Source Wood Pulping - NSSC

Very little info is available for emissions and controls from NSSC pulp plants.

Our best estimate is to consider NSSC plant emissions to be partially represented (SO_2) by Sulfite plants.

[illegible] can state that recovery is not practiced and that emissions are limited to absorbers, blow tanks, evaporators and fluid bed reactors.

Since recovery is not practiced (no recovery furnace) we believe that particulate emissions will be negligible and therefore eliminate this pollutant.

We will use emission factor from Pulping - Sulfite to provide best estimate of NSSC - SO_x emission until more definitive data becomes available.

SO_x / E_u : from Sulfite - "Emission Factors" pg 8
143 lb/ton pulp avg from digester

$$\boxed{E_u = 143 \text{ lb/ton pulp}}$$

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Computation Sheet for Emission Factors

Calculations Done By W. [illegible] Date 2-3-75

Source Wood Pulping - NSSC

SO$_x$ cont'd

E_M: Wood Pulping - Sulfite "Emission Factors" pg 4

assume same level of SO$_x$ control for NSSC plants can be achieved as for sulfite

$$\boxed{E_M = 20 \text{ lb/TON pulp}}$$

E_S: Ref. [illegible] ¶ 1148 SO$_x$ regulations are not applicable so that $E_S = E_U$

$$\boxed{E_S = 143 \text{ lb/TON pulp}}$$

APPENDIX 4-1

DETERMINATION OF INPUT VARIABLES
FOR
ASSEMBLY PLANTS

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Project Number - 32357 New Source Performance Standards

Computation Sheet for Industrial Factors

Calculations Done By William Massone Date 8-8-74

Source Automobile Assembly Plants

K: Ref 144 Vol 54 No 7
Pg 48 Table 1

Average Capacity Utilization Factor Dec 1965 to Dec 1973 is reported to be 91% for motor vehicles. It has peaked at 107% and bottomed at 69% however this average for the eight year period (1965-1973) is a best estimate for this industry. We will use this value and assume it to be applicable to 1975 to 1985

$$\therefore \boxed{K = .91}$$

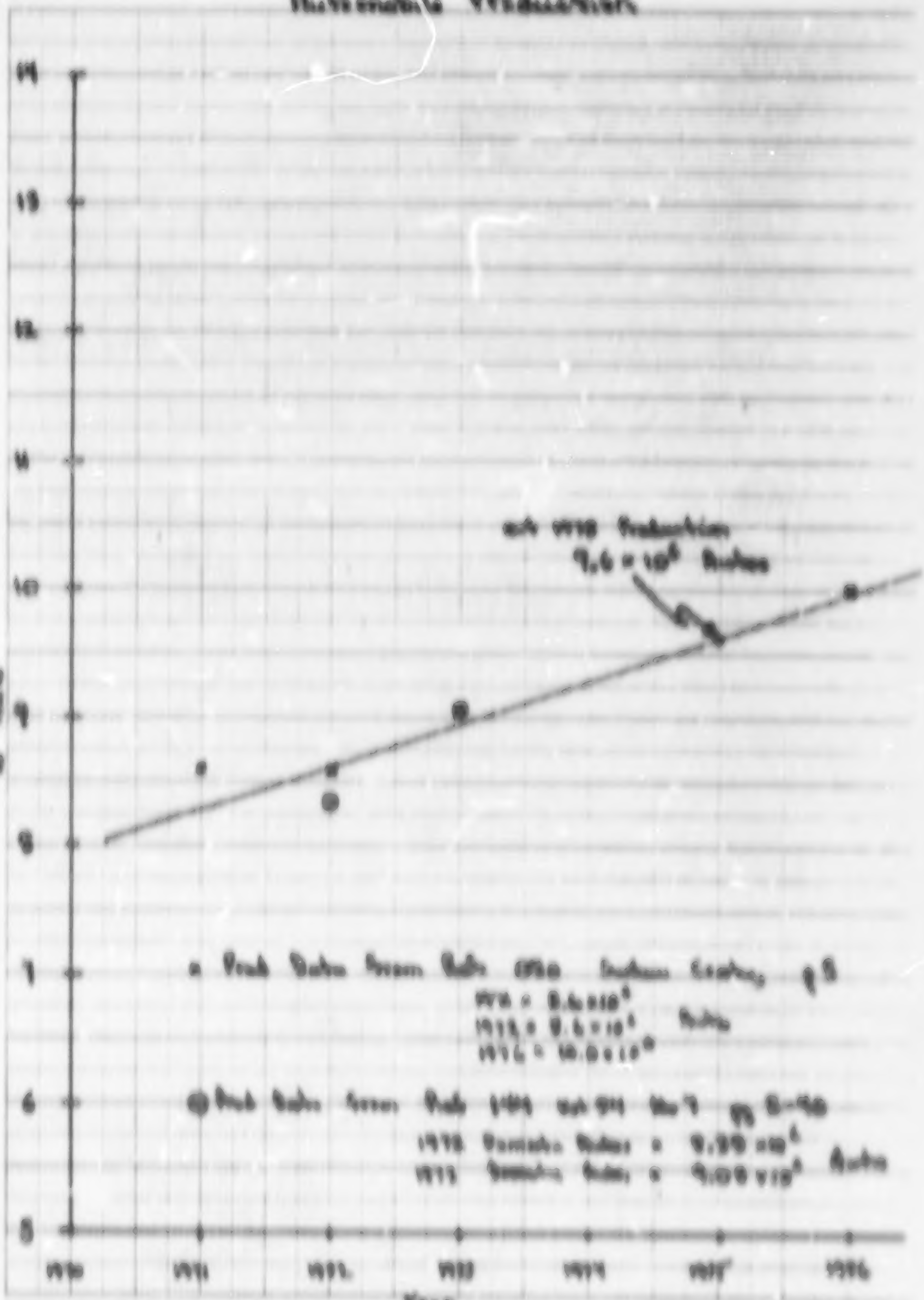
A: For the short period (1971-1986) we may interpolate by a straight line the estimated 1975 production of autos on the attached graph. This graph was developed from data in Ref 090 and Ref 144 as indicated:

$$P_{75} = 9.6 \times 10^6 \text{ autos}$$

Applying K = .91 we determine the 1975 Prod Cap

$$\boxed{A = \frac{9.6 \times 10^6}{.91} = 10.6 \times 10^6 \text{ autos}}$$

Automobile Production



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Computation Sheet For Industrial Factors

Calculations Done By William Marrone Date 8-8-74

Source Automobile Assembly Plant

P_c: Ref 144 Vol 54 No 7 Table 1 pg 48

Implied growth in capacity from 1966 - 1973 (8 year period) was 26%

We reason that 1973 Cap = 1.26 × 1966 Cap

$$\frac{1.26 \times (1966)}{(1966)} = (1 + P_c)^8$$

$$\sqrt[8]{1.26} = 1 + P_c \Rightarrow P_c = .029$$

compou

$$\boxed{P_c = .029 \text{ compound}}$$

P_B: Ref 037
1974 Ed

37.1 (37.11)

12 year asset guideline

2 × IRS = 24 yrs 100% Dep in 24 yrs simple rate

$P_B \Rightarrow \frac{100\%}{24} \cong 4\%$ sim

$$\boxed{P_B = .04 \text{ simple}}$$

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Computation Sheet For Emission Factors

Calculations Done By D Marrone Date 8-8-74

Source Automobile Assembly Plant

Hydrocarbons

E₄ 8

Approximately 3.5 gal of paint is required to paint the "average" autobody Ref 075 Surface Coating [illegible]

Assuming that all of the solvent from the paint, primer etc is emitted and knowing the quantity of solvent in the coating we may estimate the HC emissions from this source.

Ref 075 p4.2-1	Paint	12 lb/Gal	[illegible] = .56	56% solvent
	Lacquer	*7 lb/Gal	[illegible] = .77	77% solvent
	Primer	*8 lb/Gal	[illegible] = .66	66% solvent
	Enamel	*13 lb/Gal	[illegible] = .42	42% solvent

* estimated values by author.

Rather than attempt to weight the solvent content by use we will make the following assumptions,

(1) 10 lb/Gal coating density

(2) 60% solvent content

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Computation Sheet For Emission Factors

Calculations Done By William Manners Date 8-8-74

Source Automobile Assembly Plants

E_{14} cont'd:

Therefore using 3.5 Gal coat / Auto

10 lb coat / Gal coat

$.6 \frac{\text{lb solvent (HC)}}{\text{lb coat}}$

$E_{14} = .6 \times 10 \times 3.5 = 21$ lb HC / Auto

$$\boxed{E_{14} = 21 \frac{\text{lb}}{\text{Auto}}}$$

E_{15}: Two emission points for these plants are identified as sources of solvent (HC) pollutants from surface coating operations: ① Application Booths
② Oven

Control of oven emissions is readily achieved by conventional systems while spray booth emissions are not feasibly controlled with these systems. Spray booths generally have exhaust volume flowrates of excessive size. Current trends in this industry is to develop new coating operations which would eliminate solvent emissions.

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Computation Sheet For Emission Factors

Calculations Done By R. J. Gibson Mannone Date 8-8-74

Source Automobile Assembly Plants

The following surface coating operations are thought to be in the developing stage as competing with current spray booth systems;

a) electrostatic spraying
b) powder electrostatic
c) electro coating
d) flow coating

Ref 050 Surface Coating pg 13 states that a 98% overall efficiency or better could be attained by some suitable combination of modified application method and conventional oven control system.

We will use the figure of 98% efficiency as a overall attainable control level by modifying the surface coating process in the automobile industry

$$E_N = .02 \times E_u = .02 \times 21 \text{ lb/Auto}$$
$$= .42 \text{ lb HC/Auto}$$

$$\boxed{\therefore E_N = .42 \text{ lb/Auto HC}}$$

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Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10-28-74

Source Auto Assembly Plants

Hydrocarbons:

As discussed in Vol# 1,

$$E_S = E_S^u + E_S^p + E_S^n .$$

To determine E_S, we must ~~[illegible]~~ first obtain a breakdown of auto assembly operations on a state-by-state basis. This information was not directly available to us. Instead, we have used as an indicator of auto assembly plant distribution the state-by-state figures for value-added production of the motor vehicles industry in 1963, as obtained from reference 155. The eight states with the highest value-added production for motor-vehicles account for over 80% of the total national production, and we therefore only consider these (*many of the smaller contributions are not available.) The table below lists the figures for value-added and the fractional capacity A_i calculated on this basis:

STATE	1963 * value-added M.V. production (10^9 dollars)	A_i (estimated)
MICHIGAN	4.9	.47
OHIO	1.9	.18

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R. J. Londergan Date 10-22-74

Source Auto Assembly

HC (Cont.)

TABLE (cont.)

STATE	(10^9 dollars)* 1963 value-added M.V. production	A_i (est.)
IND.	0.8	.07
WIS.	0.7	.07
CAL	0.6	.06
N.Y.	0.6	.06
MO.	0.6	.06
ILL.	0.4	.04

* Ref 155

Using this estimate for Ai, we can proceed to calculate the various contributions to E_S.

(i) $E_S^u = E_u \sum_{i=1}^{N_u} A_i$

Of the states listed above, Michigan & Missouri, have no applicable HC regulation.** Thus

$$E_S^u = (21)(.53) = 11.1 \text{ LB/AUTO}$$

where E_u = 21 LB/AUTO from an earlier emissions factor calculation.

** Ref 84 & 148.

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R.J. Londergan Date 10-22-74

Source Auto Assembly

HYDROCARBON (Cont.)

(ii) All of the remaining states listed have regulations which require 85% emissions control at [illegible] levels appropriate to this ~~industry~~ process.* Therefore we obtain

$$E_S^P = E_u \sum_{j=1}^{M} A_j (1 - P_{aj})$$

$$= (21)(0.15)(0.48) = 1.5 \text{ LB/AUTO}$$

For the total E_S we then obtain

$$\boxed{E_S = E_S^u + E_S^P = 12.6 \text{ LB/AUTO}}$$

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Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 6/6/78

Source Cable Cover Production

Ref (276) p 46

1967 Pb Consumption = 63,037 tons

1971 Pb Estimate = 52,920 tons

$$P_c = \sqrt[4]{\frac{52.92}{63.04}} - 1.0 = -0.043$$

$$\boxed{P_c = -0.043}$$ comp'd

$$1975 \text{ Cons.} = 52{,}920(1-.043)^4 = 44{,}388$$

$$\boxed{A = 0.0444 \times 10^6 \text{ tons Pb}}$$

Ref (276) p 42 Due to lead recycling during the coating process, K must be modified to reflect the situation.

Ref (276) p 42 estimates a factor of @ least 10

$$\boxed{K = 10.0}$$

Due to the lack of economic incentive, we will assume

$$\boxed{P_B = 0.0}$$

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Computation Sheet For Emission Factors

Calculations Done By Hopper Date 6/5/75

Source Cable Cover Production

From Ref (281) p12

$$\boxed{E_{U/R} = 0.0439 \text{ LB/TON LEAD}}$$

From Ref (278) p48

$$E_{W/R} = (1-.75)(0.0439) = .0109$$

$$\boxed{E_{W/R} = 0.0109 \text{ LB/TON LEAD}}$$

Ref (276) p43 indicates ~30 plants in the U.S. & 2/3 presses per plant. The avg melt kettle size is 3,000 → 15,000 lbs
Assuming the avg of 9,000

Ref (276) p46 indicates that most plants are located in Conn, NY & NJ

Using the PWE curves from Ref (94) & (95)

Allowable =

Conn = 9.7
NY = 10.8
NJ = 30

Avg = 16.8 lb/hr particulate

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Computation Sheet For Emission Factors

Calculations Done By [illegible] Date 6/5/85

Source Cable Cover Production

Ref (281) p12

Avg % Pb of Part. = $(4.99 + 17.2 + 25.6)/3$ = 15.93%

$(.1593)(16.8) = 2.676$ lb Pb/hr Assuming "de facto" Pb control resulting from particulate reg's

$$\frac{2.676 \text{ lb/hr } (2000)}{(9000)} = 0.595 \text{ lb/ton}$$

Since $E_S \ngtr E_U$ $E_S = E_U$

$$\boxed{E_{S_{Pb}} = 0.0439 \text{ lb/ton lead}}$$

Particulate

Neg Pc. Not aplicable for NSPS
Zero Pb

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By Hopper Date 6/5/75

Source Can Mfg (Soldering Opns)

Ref (276) p 73

Cans soldered in 1973 = 65 ×10⁹

Estimated # of cans soldered in 1980 = $\frac{(30+40)\times10^9}{2} = 35\times10^9$

$$P_c = \sqrt[7]{\frac{35}{65}} - 1 = \sqrt[7]{.5385} - 1 = -.085$$

$$\boxed{P_c = -0.085}$$ cmpd

There would be no economic incentive to replace obsolete capacity, we will assume

$$\boxed{P_b = 0.0}$$

Ref (276) p 73 in 1975, 50×10⁹ cans

Ref (277) App(B) 1.8 lb/1000 cans

$$\frac{(50\times10^9)(1.8\times10^{-3})}{2000} = 45{,}000 \text{ tons of Pb}$$

Ref (144) p 42 Using the avg 1965-1973 K for the [illegible] of beverage industry as representative

$$\boxed{K = 0.81}$$

$$A = \frac{45000}{.81} = \boxed{0.0555\times10^6 \text{ tons Pb} = A}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hopper Date 1/5/75

Source Can Mfg (Soldering Op'ns)

Ref. (276) p 75 gives Wiping Station Emissions of
412 LB/YR of LEAD @ 50% control for 1.44×10⁸ CANS/YR

+

96.4 LB/YR of LEAD @ 0% control for 1.44×10⁸ CANS/YR
@ the solder bath

$$\frac{\left[\left(\frac{412}{.5}\right)+(96.4)\right]2000}{(1.44\times10^{8})(1.8\times10^{-3})} = 7.1\ \text{LB}/\text{TON Pb}$$

$$\boxed{E_{U_{Pb}} = 7.1\ \text{LB}/\text{TON Pb}}$$

Ref (276) p 78 If we assume an overall control of 75% using low energy wet scrubbers, then . . .

$$E_{N_{Pb}} = 7.1\,(1-.75) = 1.78$$

$$\boxed{E_{N_{Pb}} = 1.78\ \text{LB}/\text{TON Pb}}$$

@ 1.44×10⁸ CANS/YR & 1.8×10⁻³ LB Pb/1000 CANS

$(1.44\times10^{8})(1.8\times10^{-3}) = 259,200$ LBS Pb/YR·PLANT

From Ref (276) p 75 Model can line operates 4800 hrs/yr

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hanna Date 6/5/75

Source Can Mfg. (Soldering Op'n)

$$PWR = \frac{259,200}{4800} = 54\ \mathrm{lb/HR}$$

From the gen'l PWR curve (Ref (84) & (148))

Allowable = 0.044 #/HR (Assuming 'de facto' control of Pb thru part. regs)

$$E_{Pb} = \frac{0.044(2000)}{(54)} = 1.63$$

It would appear that the States are not enforcing particulate regs within this industry probably because of the low PWR.

Ref (276) p 75 indicates that dry cyclones @ ~90% efficiency are generally used on the wiping station emissions. Since this is present industry practice, we will def'n Es as follows

$$\frac{\left[(412 + 96.4)\right]2000}{(1.44\times10^{3})(1.8\times10^{2})} = 3.92$$

$$\boxed{E_{S_{Pb}} = 3.92\ \mathrm{LB/TON}/\mathrm{Pb}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By R.J. Marrone Date 8-7-74

Source Lead Acid Battery

The major production of storage batteries is for lead-acid storage batteries as indicated by it representing 93% of the value of shipment Ref 039 pg 2

Lead and lead oxide are consumed in battery manuf. Ref 039 p 7 Table 1.6 has the 1965-1971 lead consumption data which when combined with auto battery production figures (assumed to be total lead-acid product) on pg 8 Table 1.7 of the above source, may be used to calculate lead and lead oxide requirements per battery;

YR.	Batteries (MM)	Tons Pb.	lb Pb/Batt	Tons PbO	lb PbO/Batt
1967	40.0	229,987	11.5	231,978	11.4
1968	44.5	250,129	11.2	263,976	11.8
1969	45.4	280,986	12.3	302,160	13.3
1970	45.6	283,451	12.4	310,002	13.6
1971	49.7	283,110	11.4	342,149	13.7
		Avg	11.8 lb/Batt	Avg	12.9 lb/Batt

We will use 12 lb Pb/Batt and 13 lb PbO/Batt which are the material consumptions in the battery manufacturing process.

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Project Number - 3P391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By RJ Marrone Date 8-8-74

Source Lead Acid Battery

P_c: Pg 1. and Table 1.2 pg 2 of Ref 039 indicate that the annual growth for lead-acid batteries is estimated to be 5%. This growth is assumed to continue for the period 1975 to 1985. Development in electric car technology would result in a higher growth rate, however feasible system are not in evidence nor do we expect a significant cut into the internal combustion market by 1985.

$P_c = .05$ compound

Ref 044 pg 41 indicates a 5.1% growth (compound) for the present period

Ref 039

K: A fractional utilization factor is obtained by referring to Table 3-1 which gives the materials processed through various operations and the capacity of 5000 Batt/day. The Process flow chart Fig 2.1 pg 10 indicates the stage at which Pb and PbO are inputted

Lead (Pb) is inputted in the Lead Melt Pots and Oxide Paste Mixing.

Lead Oxide is inputted in the Oxide-Paste Mixing

From Table 3-1 pg 16 Pb input = 20,000 + 25,000 = 45,000 lb/da

PbO input = 50,000 lb/day

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Massagno Date 8-8-74

Source Lead Acid Battery

K_1 cont'd

With this data and our estimate of the Pb and PbO input/ per battery we may calculate the estimated production at the plants depicted on Table 3-1

$$\text{Pb}: \frac{45{,}000 \text{ lb Pb/day}}{12 \frac{\text{lb Pb}}{\text{Batt}}} = 3750 \text{ Batt/day}$$

$$\text{PbO}: \frac{50{,}000 \text{ lb PbO/day}}{13 \frac{\text{lb PbO}}{\text{Batt}}} = 3846 \text{ Batt/day}$$

K factors are obtained by relating production to capacity where capacity was reported as 5000 Batt/day.

$$K_1 = \frac{3750}{5{,}000} = .75$$

$$K_2 = \frac{3846}{5000} = .77$$

Avg K = .76

We will use the avg value of K obtained above.

$$\boxed{K = .76}$$

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Project Number - 32301 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Massone Date 8-8-74

Source Lead- Acid Battery

A :

Taking the 1969 Battery shipments (Original + replacement) from Table 1.3 pg 3 of Ref 039 and applying the $P_c = .05$ for the period 1969 - 1975 we may calculate the 1975 estimated production of lead - acid batteries

$$P_{75} = 45.4 \left(1 + .05\right)^6 \times 10^6$$

$$P_{75} = 60.8 \times 10^6 \text{ batt/yr}$$

Applying $K = .76$ we calculate the 1975 Production capacity (A)

$$A = \frac{P_{75}}{K} = \frac{60.8 \times 10^6}{.76}$$

$$\boxed{A = 80 \times 10^6 \text{ batt/yr}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By W. Maxwell Date 9-27-79

Source Lead Acid Battery Plants

P_B :

Ref 037 pg 34-35 Section 36.1

We assume that this industry is covered under the above table which does refer to storage batteries.

Asset guideline period 12 yrs
P_B est → 2 × IRS = 24 yrs

$\frac{100\%}{24 \text{ yrs}} \cong 4\% / \text{yr}$ simple

$\therefore P_B = .04$ simple

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Project Number - 12391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Marrama Date 8-8-74

Source Lead Acid Battery

Particulates

E_u: Table 3.2 pg 17 of Ref 039 tabulates the results of emission data from 9 lead-acid battery manufactures. Lead oxide (PbO) emitted from oxide paste mixing, assembly, lead melting pots is in the particulate matter. Uncontrolled PbO particulate emissions are obtained from Plants #1, #6, #7, #8 which had no control device or just a simple filter pack as in Plant #7. The emission factor is E = 20 lb PbO/Ton PbO

Using the weight contribution of PbO to the manuf of batt (13 lb PbO/Batt) we calculate the emission factor in terms of lb/PbO per battery

$$E_u = \frac{20 \text{ lb PbO}}{\text{Ton PbO}} \times \frac{13 \text{ lb PbO}}{\text{Batt}} \times \frac{\text{Ton PbO}}{2000 \text{ lb PbO}}$$

$$\boxed{E_u = .13 \text{ lb/Batt PbO (particulate) emission factor uncontrolled}}$$

E_c:

Plants #2, #3, #4 and #9 control the PbO emissions by baghouse filters. #4 also has controlled temperature

#2 .20 lb/T
#3 .20 lb/T
#4 .02 lb/T
#9 .05 lb/T

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R.J. Massone Date 8-8-74

Source Lead Acid Battery

E_N: cont'd particulate

Plants #4 and #9 are more efficiently controlled

$$\#4 = \frac{10-.01}{10} = 99.9\%$$

$$\#9 = \frac{10-.08}{10} = 99.2\%$$

Baghouses or air scrubbers are generally used in lead-acid plants and the practical efficiency is 98.2-99.8% etc

We will use 99.9% efficiency as attainable in 1975-1985

$$E_N = .001 \times E_U = .001 \times .13$$

$$\boxed{E_N = .00013 \text{ lb/Batt}}$$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 8-8-74

Source Lead Acid Battery

Lead Fumes

E_u 1 Referring to Ref 034 pg 17 Table 3.2 we obtain emission factors for lead from 9 lead battery plants.

Plant	Control	lb Pb/Ton
#1	None	.92
#2	Baghouse	.90
#3	Baghouse	.80
#4	Baghouse & Temp Ctrl	.55
#5	Lead Traps	.96
#6	None	1.00
#7	Filter Pads	.70
#8	None	.83
#9	Baghouse	.81

$E_{Avg} = .82 \frac{lb}{Ton}$

These values are statistically the same and we will develop an average lead emission factor. The fact that the emission factors for controlled plants are nearly the same for uncontrolled plants concludes either 1 of the following;

① sources of lead emissions are not generally points of emission control.

② the fume nature of the lead effluent would preclude poor collection efficiency

In any case the uncontrolled emission factor is derived from the avg of the above values.

$$E_{Avg} = .82 \frac{lb\ Pb}{Ton\ Pb}$$

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Project Number - 32391 **New Source Performance Standards**

Computation Sheet For **Emission Factors**

Calculations Done By R.J. Manzone Date 9-8-74

Source Lead Acid Battery

Lead Fumes cont'd

E_u Taking the avg emission factor and the lb Pb input/Batt we may estimate the uncontrolled emission factor for Lead

$$E_u = .82 \frac{\text{lb Pb}}{\text{Ton Pb}} \times \frac{12 \text{ lb Pb}}{\text{Batt}} \times \frac{\text{Ton Pb}}{2000 \text{ lb Pb}}$$

$$\boxed{E_u = .005 \frac{\text{lb Pb}}{\text{Batt}}}$$

E_N :

Control technology for controlling the lead fumes does not appear to be presently available.

We assume $\boxed{E_N = 0}$ for maximum impact determination

E_{IIId} is also considered equal to zero

$$\boxed{E_{IIId} = 0}$$

Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By R.J. Marrone Date 9-11-74

Source Lead Acid Battery

Acid Mist

E_u: From Table 3.1 pg 16 Ref 039 we obtain:

Typical Plant { 150 lb/day H_2SO_4 Fume
No control
5,000 $\frac{Batt}{day}$ cap

We will apply our K = .76 and the above data to determine an estimate of the uncontrolled emission factor for acid mist.

$$E_u = \frac{150 \text{ lb acid}}{\text{day}} \times \frac{\text{day}}{.76 \times 5000 \text{ Batt}}$$

$$E_u = .04 \text{ lb/Batt} \quad \text{Acid mist}$$

E_c: pg 20 Ref 039 control of H_2SO_4 fumes from forming operation is achieved by water scrubbing of room air. The water is neutralized by NH_3 and bleed. The air is recycled to the plant. H_2SO_4 is high soluble in water.

This system is assumed, especially in light of recycle, to be 99.99% eff. $E_c = .0001 \times E_u$

208 $E_{ind} = E_c = .000004$ lb/Batt $E_c = .000004$ lb/Batt Negligible

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Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 8-9-74

Source Lead Acid Battery

Hydrocarbons

E_{14}:

HC emissions may be emitted by spray booths, dryers, and heat seal machines.

Ref 039 Table 3.1

Operation	HC Emission Rate (uncontrolled)
Spray Booths	4 Gal/day
Dryer	.5 Gal/day
Heat Sealing	1 lb/day

Using 7.5 lb/gal as the density of average paints solvents, we obtain

Spray Booth	30 lb/day
Dryer	3.8 lb/day
Heat Seal	1
	34.8 ≈ 35 lb/day

Capacity = 5000 Batt/day

Production = .76 × 5000 = 3800 Batt/day

$$E_{14} = \frac{35 \text{ lb HC/day}}{3800 \text{ Batt/day}}$$

$$\boxed{E_{14} = .009 \text{ lb/Batt}}$$ Hydrocarbons

negligible!

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Computation Sheet For Emission Factors

Calculations Done By W. Mathews Date 8-8-74

Source Lead Acid Battery

Hydrocarbons

E_H: We assume that incineration or carbon absorption may be applied to these sources

Efficiencies to be expected by these systems would be on the order of 95-99%. We will assume 99%.

$E_H = .01 \times E_u = .01 \times .009$ lb/batt

$E_H = .00009$ lb/batt

(negligible)

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Computation Sheet For Emission Factors

Calculations Done By R.J. Mazzone Date 11-25-74

Source Lead Acid Battery

E_s :

Refs. 148 & 084

Regulations do not apply to emissions of lead fume and acid mist from acid battery plants so that the allowable emissions are assumed equal to the uncontrolled level.

(Lead Fume) $E_s = .005 \frac{\text{lb Pb fume}}{\text{Battery}}$

(Acid Mist) $E_s = .04 \frac{\text{lb Acid Mist}}{\text{Battery}}$

(Particulate)

The process weight for lead acid battery manuf. is considered to be the sum of the lead and lead oxide inputs calculated previously.

$$12 \text{ lb Pb/batt} + 13 \text{ lb PbO/batt} = 25 \frac{\text{lb process input}}{\text{batt}}$$

Using a typical plant size of 5000 battery/day and $16 \frac{\text{hr}}{\text{day}}$ operation

$$\frac{25 \text{ lb input}}{\text{Battery}} \times \frac{5000 \text{ Battery}}{\text{day}} \times \frac{\text{day}}{16 \text{ hr}} \cong 7813 \text{ lb/hr}$$

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Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 11-27-74

Source Lead Acid Battery

E_s :
(particulate)

From the generalized process weight rate curve the allowable hourly emission rate is about 10.1 lb/hr for the process weight rate of 7813 lb/hr.

$$\frac{10.1\ \frac{lb}{hr} \times \frac{16\ hr}{day}}{5000\ Batt/day} = .032\ \frac{lb\ particulate}{Battery}$$

$$\boxed{E_s = .032\ lb\ Partic./Battery}$$

E_s :
Hydrocarbon

$\frac{30}{35} \cong 86\%$ of solvent emission from spray booth

We assume solvent emissions are in the reactive category. (non-heat process) for E_s determination.

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Computation Sheet for Emission Factors

Calculations Done By W. Marrone Date 11-23-74

Source Lead Acid Battery

E_5' cont'd

Hydrocarbons

Ref. 039 Appendix Table 1.1 Ref. 148 & 084

State	No. of Battery Plants	Allowable Emissions
Alabama	1	40 lb/day
Alaska	2	No Reg
Arizona	1	No Reg
Arkansas	1	No Reg
California	54	40 lb/day
Colorado	4	No Reg
Connecticut	5	40 lb/day
Delaware	1	No Reg
Florida	13	No Reg
Georgia	6	No Reg
Illinois	15	8 lb/hr (128 lb/day)
Indiana	9	15 lb/day
Iowa	2	No Reg
Kansas	2	No Reg
Kentucky	5	40 lb/day
Louisiana	2	15 lb/day
Mass.	6	No Reg
Michigan	8	No Reg
Minnesota	3	No Reg
Mississippi	2	No Reg

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Computation Sheet For Emission Factors

Calculations Done By W. Marrone Date 11-25-74

Source Lead Acid Battery

E_3 Hydrocarbon cont'd

State	No. of Battery Plants	Allowable Emissi
Missouri	5	No Reg
Nebraska	1	No Reg
New Jersey	5	No Reg
New Mexico	1	No Reg
New York	9	No Reg
N. Carolina	3	40 lb/day
Ohio	5	40 lb/day
Oklahoma	1	40 lb/day
Oregon	8	No Reg
Pennsylvania	14	40 lb/day
Rhode Island	2	No Reg
S. Carolina	2	No Reg
Tennessee	6	No Reg
Texas	20	100 lb/day
Vermont	1	No Reg
Virginia	3	40 lb/day
Washington	5	No Reg
W. Virginia	1	No Reg
Wisconsin	6	30 lb/day
Total	240	

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By D. Marrone Date 11-23-74

Source Lead Acid Battery

E_s: cont'd

hydrocarbon

① For those plants (states) with no reg, E_s assumed equal to E'_u

$$97 \text{ plants} = E_s = E'_u = 35 \text{ lb/day}$$

$$A_i = \frac{97}{240} = .404$$

② For those plants (states) with $E_{si} \geq 35$ lb/day $E_{si} = E'_u = 35$ lb/day

$$126 \text{ plants} = E_s = E'_u = 35 \text{ lb/day}$$

$$A_i = \frac{126}{240} = .525$$

③ plants with $E_{si} < E'_u$ (35 lb/day)

11 plants	15 lb/day	$A_i = \frac{11}{240} = .046$
6 plants	30 lb/day	$A_i = \frac{6}{240} = .025$

$$E_s = .404(35) + .525(35) + .046(15) + .025(30)$$

$$E_s = 14.14 + 18.38 + .69 + .75$$

$$E_s = 33.96 \text{ lb/day} \quad E_s = \frac{33.96 \text{ lb/day}}{5000 \text{ batt/day}} = .0068 \frac{\text{lb}}{\text{batt}}$$

$$\boxed{E_s = .0068 \text{ lb/batt}}$$

1 of 1

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Industrial Factors

Calculations Done By HUNTER Date 8/27/75

Source Type Metal Production

Ref (77) Section III-B gives the following info as taken from the Minerals Yearbook

$\boxed{P_c = -0.06}$ simple

$\boxed{K = 1.0}$

$\boxed{A = 0.014 \times 10^6 \text{ tons/yr}}$

From Ref (77) utilizing the IRS depreciation life gives a replacement rate of 4.5%. However, since the industry is declining @ a 6% rate, they would not in all probability replace obsolete capacity for economic reasons.

$\boxed{P_r = 0.0}$

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Project Number - 32391 New Source Performance Standards

Computation Sheet For Emission Factors

Calculations Done By Hance Date 5/27/75

Source Type Metal Production

Ref (278) p 85

For a single plant, emissions were 1425 lbs Pb per year from a plant that purchased 104 tons of metal. The controlled E.F. is 17 #/ton Pb in alloy

$$\frac{1425}{104(\%\,\text{lead})} = 17 \qquad \%\,\text{lead} = 80\%$$

$$\eta_{\text{collection}} = 78\%$$

$$E_{U_{Pb}} = \frac{17}{.22} = 77.3$$

$$\boxed{E_{U_{Pb}} = 77.3\ \text{lb}/\text{ton Pb in alloy}}$$

If we assume that all plants (existing) can achieve 80% η then

$$E_{III_d} = 77.3(1-.8) = 15.5$$

$$\boxed{E_{III_d} = 15.5\ \text{lb}/\text{ton Pb in alloy}}$$

Rf. (277) Section IX-3 gives E_S as 38.8

$$\boxed{E_{S_{Pb}} = 38.8\ \text{lb}/\text{ton Pb in alloy}}$$